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ABSTRACT

This publication contains abstracts of papers presented at the 52nd annual meeting of the National Association for Research in Science Teaching (NARST), Atlanta, Georgia, March 21-23, 1979. Papers relate to science teacher education (preservice and inservice), cognitive development, learning, instruction, teacher and student behaviors, research design and other topics. (PEB)

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NATIONAL ASSOCIATION
FOR RESEARCH IN SCIENCE TEACHING

52ND ANNUAL MEETING

ABSTRACTS OF PRESENTED PAPERS

U S DEPARTMENT OF HEALTH.
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
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The Atlanta Hilton
Atlanta, Georgia
March 21-23, 1979

ERIC Clearinghouse for Science, Mathematics
and Environmental Education
College of Education
The Ohio State University
1200 Chambers Road, Third Floor
Columbus, Ohio 43212

SE 026 771

PREFACE

The ERIC Clearinghouse for Science, Mathematics, and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the annual conference in Atlanta, Georgia, March 21-23, 1979.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC staff to provide a general format for the abstracts. Special recognition should be given to Dr. John Renner and the NARST Program Committee who obtained the abstracts and organized the program.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Resources in Education, Current Index to Journals in Education and other publications of the ERIC system.

March, 1979

Arthur L. White
Editor

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TABLE OF CONTENTS

Page

PREFACE ii

PAPERS PRESENTED AT THE CONFERENCE

GENERAL SESSION I

"What Are the Implications of Paradigm-Based Research for Science Education Research?"
Berger, Carl F. 1

CONCURRENT SESSION A 2

Session A-1. Paper Set: Project LEO
Matthews, Charles. 3
Vinelli, Jose. 5
McKee, David J. 7

Session A-2. Perception and Student Behavior
Champagne, Audrey B. and Leo Klopfer 10
Doran, R. L. and S. J. Alaimo. 13
Betkouski, Marianne. 15

Session A-3. Teacher Characteristics
Cotham, Joseph C. 18
Dobey, Daniel C. 20
Naegele, Carl and Joseph C. Cotham 22

Session A-4. Paper Set: Cognitive Science Methodologies
Dennison, Judy H. and Edward L. Smith. 25
Finley, Fred N. 27
VanKirk, Judith. 29

Session A-5. Piagetian Research
Leasure, Diane; Dale Baker and Walt Lockwood 32
Padilla, Michael and Lloyd Ollila. 34
Staver, John and Dorothy L. Gabel. 37

CONCURRENT SESSION B 38

Session B-1. Paper Set: Predictors of Science and Mathematics Achievement and Science Career Expectations of Innercity Adolescents
Watson, Fletcher G. 39
Lee, Mae 40
Jordan, Theresa J. and Tina Jacobowitz 42
Lee, Mae and Theresa J. Jordan 44

Session B-2. Student Characteristics and Performance
Jones, Dan 46
Wormack, Leslie. 48
Doody, William J. 51

4

Session B-3. Pre-service Teacher Education

Sunal, Dennis W. 54
Horak, Willis J. 57
Okey, James R. and William Capie 60

Session B-4. Symposium: Operations Research Models

Moser, Gene; David W. Kopp and Michael D. Duffy 63

Session B-5. General Research

Ziccarelli, Gabriel and Gene W. Moser. 66
Bowyer, Jane; Larry Lowery; and Mike Padilla 68
Trojcak, Doris A. 70
GENERAL SESSION II. 72

"The Reception Learning Paradigm" - Novak, Joseph D.
"The Hierarchical Learning Paradigm" - Jones, Howard
"The Developmental Learning Paradigm" - Lawson, Anton E.

CONCURRENT SESSION C

Session C-1. Instruction

Pridmore, Brooke M. and Edward C. Lucy 74
Ross, Joan F. and Leverne J. Thelen. 76
Lee, Janice T. and Norman D. Anderson. 78

Session C-2. General Research

Ritz, William C. and Jane G. Cashell 81
LaShier, William S. 84
McDuffie, Thomas and James V. DeRose 86

Session C-3. Paper Set: Follow-up Studies in Teacher Education Models for Teacher Evaluation

Blosser, Patricia E. 89
Ayers, Jerry B. 90
Howe, Robert W. 91
Penick, John E. 92

Session C-4. Learning

Jacknicke, K. G. and D. A. Pearson 94
Koran, John J., Jr.; S. Dennis Baker;
and Mary Lou Koran 96
Carmi, Gideon. 99

Session C-5. Techniques and Procedures of Research

Howe, Ann C. 101

CONCURRENT SESSION D

Session D-1. Paper Set: The Socio-Scientific Reasoning Model Past, Present and Future

Cheu, Janey M. Y.; Louis A. Iozzi and June P. Maul. . . 103
Maul, June P.; Louis A. Iozzi; and Janey M.Y. Cheu . . 104
Henkin, Gayle; Louis A. Iozzi; June P. Maul;
and Janey M.Y. Cheu. 105
Iozzi, Louis A.; Janey M.Y. Cheu; and June P. Maul. . 106

Session D-2. General Research

Stedman, Carlton H. 108
Likins, Stephen F. 110
Mali, Ganesh Bahadur. 111

Session D-3. Inservice Teacher Education

Lindbeck, Joy S. 114
Glass, Lynn W. 116
Butzow, John W. and Bernard Yvon. 118

Session D-4. Symposium: Data Collection

Jacobson, Willard J.; Richard J. Andren; Gary C. Bates; Mitchell E. Batoff; and Kelvin C. James. . . . 121

CONCURRENT SESSION E

Session E-1. Paper Set: Metaphorical Abilities

DuBrucq, Denyse C. 123

Session E-2. Teacher Attitudes

Rowe, Ronald E. 127
Jaus, Harold H. 129
O'Sullivan, Patricia; Martha K. Piper; and Joseph P. Carbonari 131

Session E-3. Instruction

Price, Charles L. 134
Riley, Joseph P. II 136
Tobin, Ken G. 139

Session E-4. Techniques and Procedures of Research

Berger, Carl F. 142

Session E-5. Paper Set: Teaching Procedures

Schneider, Livingston and John W. Renner. 144
Marek, Ed and John W. Renner. 146
Grant, Rosalie and John W. Renner 147

CONCURRENT SESSION F

Session F-1. Paper Set: Video Cassettes in College Science

Wagner, John and Warren D. Dolphin. 150
Dolphin, Warren D.; John Wagner; and Dave Ludwig. 152

Session F-2. General Research

Campbell, Richard L. and Luis A. Martinez-Perez 155
Campbell, Richard L.; Dennis D. Murphy; and Willie E. Williams. 157
Krajkovich, Joseph G. and Jeffrey K. Smith. 159

Session F-3. Techniques and Procedures of Research

Capie, William and James R. Okey. 161

Session F-4. Research Methodology

Torrence, David R. 163
Bredderman, Ted 166
Kozlow, M. James and Arthur L. White. 168

C, 6

Session F-5. Piagetian Research
DeLuca, Fredrick P. 171
Bass, Joel E. 173
Treagust, David F. 175

CONCURRENT SESSION G

Session G-1. Paper Set: College Laboratory Instruction
Kyle, William C., Jr.; James A. Shymansky;
and John E. Penick. 177

Session G-2. Elementary Science Instruction
Welliver, Paul W. and Menahem Rabinovich. 181
Allen, Ralph and Joseph Callahan. 182
Price, Patricia P. and Larry E. Schafer 185

Session G-4. Instruction
Evans, Al 188
Kauchak, Don; Paul Eggen; and Sandra Kirk 190
Kermis, William J. 193

Session G-5. Learning
Seeber, Fred; George Pallrand; Geraldine
VanDenberg; and David VanHarlingen 196
Griffiths, A. K. and Heidi Kass 197
Gabel, Dorothy. 199

RESEARCHERS POTPOURRI. 201

"NSTA-NARST Cooperative Research Efforts"
White, Arthur L., Linda R. DeTure,
Joan Duea and Russell H. Yeany

NARST AWARD PAPER. 202

CONCURRENT SESSION H

Session H-1. Paper Set: The Status of Pre-College Science, Mathematics, and Social Science Education, 1955-1975
Howe, Robert W. 204
Helgeson, Stanley L.. 205
Blosser, Patricia E. 207

Session H-2. Paper Set: Factors Affecting Achievement in Science
Enyeart, Morris A. 209
Piburn, Michael D. 211
Sherman, Alan 212
Baker, Dale R. and David VanHarlingen 213

Session H-3. Learning
Smith, Walter S. and Cynthia I. Litman. 216
Balling, John D. and John H. Falk 218
Howe, Ann C. 220

Session H-4. Instruction

Saunders, Ramona L. and Russell H. Yeany 223
Long, Joe C.; James R. Okey; and Russell H. Yeany 226
Yeany, Russell H.; Richard J. Dost; and Robert W. Matthews 229

Session H-5. Round Table: Annual Review of Science Education Research

Peterson, Rita W. 233

GENERAL SESSION III 234

"The Impact of Paradigm-Based Research Upon Classroom Practice" 234
Peterson, Rita W.

GENERAL SESSION I

Presiding:
Roger G. Olstad
Past President, NARST
University of Washington
Seattle WA 98195

Topic:
What Are the Implications of Paradigm-Based Research for Science Education Research?

Speaker:
Carl F. Berger
Professor of Science Education
University of Michigan
Ann Arbor MI 48109

CONCURRENT SESSION A

Session A-1 Paper Set: Project LEO Studies of Science Learning Environments and Outcomes 1968-1978

Presiding:
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Project LEO Studies of Science Learning Environments and Outcomes, 1968-1978

Charles Matthews
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A Comparative Laboratory Study of the Effects of Two Teaching Strategies in Science on Students' Achievement-Motivation, Affiliation-Motivation, and Critical Thinking Ability

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A Study of the Effects of Two Teaching Strategies and Time of Day on Student Science Achievement and Selected Classroom Behaviors

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PROJECT LEO STUDIES OF SCIENCE LEARNING ENVIRONMENTS AND OUTCOMES, 1968-1978

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Project LEO is a research cooperative which has been studying science learning environments and outcomes for the last ten years. It is recognized that the physiological state and the mental/emotional state of the student are intimately related and interdependent and that these states are manifested in the behavior of the student. Project LEO has recognized and pursued the relationships between student behavior and teacher behavior as well as certain process and produce oriented aspects of learning outcomes in science. Although many studies have addressed teaching methodology and many studies have examined student achievement, no previous study has examined quantitatively-defined teacher behavioral patterns in elementary, secondary, and post-secondary science classrooms in terms of student behavior and cognitive, psychomotor, and affective learning outcomes. During the last ten years, Project LEO has studied variations of two specific quantitatively-defined teacher behavioral patterns in these situations and in terms of these student characteristics.

Summary of Methods

During 1968-72 activities of Project LEO focused on developing and validating the parameters of what has come to be referred to as student-structured learning in science (SSLS) strategies, defined in terms of specific teacher behaviors. During this same period, field studies revealed that science is most often taught via highly directive teacher behavioral patterns. This pattern was also defined in terms of specific teacher behaviors and has been identified as teacher-structured learning in science (TSLS). Since 1972 laboratory studies have been conducted with over 800 students and 25 teachers. Through teacher training and continuous teacher observation, teacher behavioral patterns have been maintained within the parameters of the quantitative definitions of TSLS and SSLS. Various dependent variables have been studied--including student behavior, student achievement, attitude toward science, locus of control, creativity, disruptiveness, confidence, problem solving ability, motivation, critical thinking, and others. Other independent variables such as time-of-day, sex, ethnicity, and cognitive developmental level have been included. The other two papers in this paper set report specific methods used in the most recent Project LEO studies.

Results

Findings have consistently indicated that students studying science under SSLS conditions exhibit higher levels of problem-solving ability, problem-solving confidence, self-initiativeness, self-directiveness, verbal creativity, and positive attitude toward science and toward independent learning. TSLS students exhibited higher levels of attention to the teacher, imitation of the teacher, copying of other students, initiating interaction with the teacher, and disruptiveness. Information acquisition and general achievement in science seem to be about the same for SSLS and TSLS taught students.

Although Project LEO studies so far have consistently indicated that students are more independent and fully functioning under SSLS than under TSLS conditions, there are specific indications that certain specific subgroups of students are more severely deprived under TSLS conditions than are other subgroups of students. For example, black male students scored highest on certain measures of learning if taught by SSLS but scored lowest on those measures if taught by TSLS. Specific findings of recent Project LEO studies are reported in the two other papers of this paper set.

Implications

Science educators who wish to enhance creativity, problem-solving ability, problem-solving confidence, student initiative, student directiveness, positive attitude toward science and toward independent learning and what might be called holistic science learning should take the necessary training to be able to implement a consistent and correct SSLS strategy. Those science educators who wish to accomplish information acquisition alone should choose either SSLS or TSLS. Science educators who wish to make science learning equally available to both black and white students of both sexes should implement (after the necessary training) SSLS.

Further study is needed to identify the more specific aspects of SSLS and TSLS which are associated with the varying outcomes of the two strategies. Other strategies should be quantitatively defined and studied in the fashion of the Project LEO studies and longitudinal studies should be carried out in a variety of different school settings.

A COMPARATIVE LABORATORY STUDY OF THE EFFECTS OF TWO TEACHING STRATEGIES IN SCIENCE ON STUDENTS' ACHIEVEMENT-MOTIVATION, AFFILIATION-MOTIVATION, AND CRITICAL THINKING ABILITY

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Rationale

It has been suggested that by the time a child reaches school age his/her behavior already possesses a complex psychobiological structure. Students' behaviors show tendencies toward dependency or independency which in turn cause students to expect certain behaviors from their teachers. These tendencies may reveal important variations in the students' achievement and affiliation motives as well as their critical thinking ability. Because of early lack of success and accomplishment, some students may have already weakened or thwarted their achievement motive to the point of "giving-up" before trying any task, while others may constantly seek supportive relationships, be disruptive, or withdrawn because their affiliation motives may have already been damaged by severe social rejection. Are these damages permanent? Can the school do something to remediate this situation? This study assumes that teachers can influence positive changes in students' motivation and critical thinking ability provided that deliberate procedures are applied to bring about the desired change.

Summary of Methods

The purpose of this study was to investigate the effects of two teaching strategies on students' achievement-motivation, affiliation-motivation, and critical thinking ability of a group of high school students enrolled in a special science course. It further considered the relationship of these three variables with the Activity Ratios (a measure of the relative amount of time a student spends doing lesson-related activities). Treatment was controlled by teacher training and daily observation utilizing teacher behavior categories from the Science Curriculum Assessment System. In both strategies, students could choose from various kinds of science activities (biology, chemistry, and physics). Under the teacher-structured strategy, once a student chose to perform a specific activity, he/she was given the objectives of that activity and specific instructions to follow in order to reach the stated objectives. His/her performance was assessed by written tests followed by oral questioning. Under the student-structured strategy, on the other hand, a student, after selecting an activity, was not given any directions as to what to do or how to perform that activity. He/she was free to modify the activity as desired and his/her performance was not assessed. Pretests were administered during the first two weeks of class and posttests at the end of the first semester. Students' behaviors were coded daily using the student behavior categories of the Science Curriculum Assessment System.

Results

Statistical analyses described in the paper lead to the following findings:

1. No significant differences in achievement-motivation, affiliation-motivation and critical thinking ability between students in the two strategies were found.
2. A significant interaction between level of achievement-motivation and students' gender was found: male students with initial low level of achievement-motivation shifted to high level of motivation.
3. A significant positive correlation was found between the Activity Ratios (a measure of the relative amount of time a student spends doing lesson-related activities) and the need-achievement posttest scores.
4. A significant positive correlation was found between the Activity Ratios and the Watson-Glaser Critical Thinking Appraisal scores (both forms Ym and Zm) for students with Activity Ratios above the median score.

Implications

This study suggests that the task of promoting a reversal of earlier behaviors in order to influence desired changes in students' motivation and critical thinking ability would be a very difficult commitment which would probably require more thorough and lengthier treatment than the one provided by an isolated class period a day. Such a setting probably should involve the school as a whole, as well as the parents of the students.

The implications of the correlations found between the time spent doing lesson-related activities and the achievement-motivation scores as well as the critical thinking ability scores seem to stress the importance of providing students with a variety of opportunities to work. This would allow students with high achievement-motivation and critical thinking ability to fulfill their needs by working with science materials to a greater extent than other kinds of students who appear to be less in need of working with the same materials at the same rate.

A STUDY OF THE EFFECTS OF TWO TEACHING STRATEGIES AND TIME OF DAY ON STUDENT SCIENCE ACHIEVEMENT AND SELECTED CLASSROOM BEHAVIORS

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Rationale

This paper presents some of the most recent results of Project LEO (Learning Environments and Outcomes), a cooperative research effort investigating various aspects of classroom environments and student learning behavior. Project LEO investigations have focused on two quantifiable classroom environments, Teacher Structured Learning in Science (TSLS) and Student Structured Learning in Science (SSLS). Although there have been numerous studies in which standardized student achievement tests were used as a measure of student performance, few of these studies have investigated performance on the tests as a function of quantifiable classroom environments, time of day, and the ethnicity and sex of students. Consideration of these variables form the basis of this study.

Summary of Methods

In this study, the effects of two contrasting teaching strategies (TSLS, SSLS) upon student performance on a standardized science achievement test and selected student behaviors were investigated. Other independent variables considered were time of day (morning, afternoon), sex (male, female), and ethnicity (black, white). The treatment was controlled during a 15-week period by teacher training and daily observation using the Science Curriculum Assessment System (SCAS). Pre- and post-tests were administered using the Comprehensive Test of Basic Skills (CTBS) Science test. Behaviors of students chosen at random were coded using the SCAS student interaction categories. Conservation task interviews were conducted during the treatment period on a one-to-one basis. IQ data (California Short-Form Test of Academic Achievement) were obtained from the school counselor. One hundred sixth grade students were taught in two SSLS and two TSLS classes. Appropriate hypotheses were made and analyses conducted using the Statistical Package for Social Sciences (SPSS) for Analysis of Covariance and Pearson Correlation Coefficients.

Results

Results of the study are described in detail in the paper and are as follows:

1. No significant differences in science achievement test scores between students in TSLS and SSLS classes, between male and female students, or between black and white students were observed.

2. Students in the morning classes scored significantly higher on the science achievement test than students in the afternoon classes.

3. Student performance on the science achievement test, performance on the conservation tasks, and IQ data were all significantly correlated.

4. No significant differences were found in considering any of the independent variables for lesson versus non-lesson behavior.

5. Students in SSLS classes created more individual activities and interacted with other students more than those in the TSLS classes.

Implications

The results of this study suggest that students can be provided with the SSLS classroom environment, in which they tend to create individual activities and interact with other students, without impairing performance on a standardized achievement test and without reducing the amount of lesson-related behavior. The implications of these results should be recognized by the science educator who wants to encourage individual creativity and student interaction without sacrificing academic performance.

The implications of students in the morning classes performing better on the science test than students in the afternoon classes have long been intuitively recognized. Students in classes emphasizing cognitive learning (e.g., science, math) may be more productive in the morning. Possibly this should be considered when scheduling classes.

CONCURRENT SESSION A

Session A-2 Perception and Student Behavior

Presiding:
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Interpretations of Observations of Moioon and Semantic Knowledge Structures of Students at Four Grade Levels

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Student Perceptions of Courses and Solutions of Environmental Problems

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A Study of the Effect of Science Knowledge and Coping Strategies Related to Stress on Student Behavior

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INTERPRETATIONS OF OBSERVATIONS OF MOTION AND SEMANTIC KNOWLEDGE STRUCTURES OF STUDENTS AT FOUR GRADE LEVELS

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Rationale and Objectives

Several different methods have been proposed (e.g., Johnson, 1969; Shavelson, 1973; Champagne et al., 1978) for probing students' semantic knowledge structures of concepts in classical mechanics. The structure of these concepts in a student's memory clearly is related to how successfully the student learns the related physics content. Also related to a student's success in learning classical mechanics is the extent to which the student can correctly interpret observations of objects in motion. However, some evidence indicates that students' interpretations of observations of physical phenomena are often fraught with misconceptions (e.g., Sen'ko, 1973; Nussbaum and Novak, 1976) that may interfere with their learning. Research is needed to elucidate students' misconceptions relating to objects in motion and to identify the relationships, if any, between the students' interpretations of these phenomena and representations of their semantic knowledge structures of mechanics concepts.

The main objectives of this research were:

1. To investigate the relationships between students' interpretations of their observations of objects in motion and their semantic knowledge structures of mechanics concepts.
2. To describe the similarity and differences in students' interpretations of their observations of objects in motion as in their semantic knowledge structures of mechanics concepts for students at four different grade levels (5th, 7th, 9th, 12th).
3. To compare the knowledge structure representations obtained from two methods of probing students' semantic knowledge structures: (a) Concept Structuring Analysis Technique (ConSAT), and (b) protocol analysis.

Design, Methodology, Instruments, Data

The participants in this study were 20 students in the 5th, 7th, 9th, and 12th grade levels of an urban elementary and secondary school. The students were individually interviewed by two researchers in three 40-50 minute sessions. Near the beginning of the first session and again near the end of the third session, the student completed a concept structuring task (see Champagne et al., 1978) to obtain representations of the student's semantic knowledge structure of key mechanics concepts.

The structured interviews consisted of asking students a series of questions concerning their observations of physical objects (e.g., blocks varying in size or mass) in motion under four different conditions.

1. free fall,
2. when an object at rest on a horizontal surface is accelerated by the force of a spring,
3. on an Atwood machine,
4. when one object on a horizontal surface is attached by a string to a second suspended object.

For each condition, the questions asked of the students focused successfully on:

> Describing and analyzing conditions under which a body at rest is set into motion.
>
> Describing and analyzing conditions under which a body in motion continues in motion and/or the conditions under which it stops.
>
> Describing the speed of an object in motion and explaining changes in its speed.

The student's verbal responses and other behaviors were recorded by one of the researchers and the sessions also were audiotaped. The audiotape transcripts and the researchers' notes provided the data for the protocol analyses. The students' concept structuring tasks provided the data for the analyses of their semantic knowledge structures.

Results

One finding of this study was that the two methods of probing knowledge structures yield two quite different kinds of information about a student. Specifically, the ConSat analyses primarily provide insights about how well the student can structure semantic information, whereas the protocol analyses reveal the student's understanding of mechanics concepts matches the physicist's canonical view of these concepts. Moreover, what a student reports in interpreting observations of objects in motion is often very different from what a physicist would report when observing the same phenomena. (Several interesting illustrations of such discrepancies are given in the paper.) Students usually do not distinguish between what is actually observable about an object in motion and what the observer believes he or she should be seeing. This characteristic of students' interpretation of observations of motion persisted across all four grade levels.

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STUDENT PERCEPTION OF CAUSES AND SOLUTIONS OF ENVIRONMENTAL PROBLEMS

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Objectives and Rationale

As we encounter more ecological crises both locally and globally, the need for environmental education is becoming increasingly important. One of the most frequent methods of accomplishing these goals is to incorporate the objectives as part of the regular school curriculum.

While much emphasis has been placed on the cognitive aspects of environmental education, it is the affective domain of perceptions, beliefs, attitudes, and values which will motivate students to desire and work towards a more livable future. A teacher should know what perceptions his students possess in order to plan and conduct instruction. Unfortunately, little research findings or appropriate instruments are available in this area. This study is an attempt to modify some existing assessment techniques and sample perceptions of a sample of junior and senior high school students.

Methodology and Data Collection

The survey instrument developed for the study consisted of two sections each with five statements which students were asked to rank based on their perception of the importance of each as a factor causing environmental problems or helping to solve these problems. The statements were modeled after the value categories used in the Allport, Vernon, and Lindzey's Study of Values instrument: Aesthetic, Economic, Political, Social and Theoretical.

Data was collected from a sample of 615 students across grade levels seven through twelve. Based on student responses, the median score for each statement was computed for each grade level and sex group. The dependent variables are the median scores of each value category for the "cause" and the "solution" section. These scores were analyzed by Chi-square calculations to assess for possible dependence of perceptions on the sex or grade level of students (the independent variables).

Results and Conclusions

With respect to statements possibly related to "causing" environmental problems, students of all grade levels perceived economic statements as most influential, aesthetic and political activities secondary and social and theoretical factors only minimally involved. Specific grade level variations were also detected.

The perception of importance of these factors to the solution of environmental problems differs considerably with the grade level of the students. Generally, the younger students (grades 7, 8 and 9) prefer aesthetic, economic and political activities to solve environmental problems while the older students (grades 10, 11 and 12) stressed theoretical and political considerations in such solutions. Differences in the perceptions of "cause" and "solution" of environmental problems were not related to the sex of the students sampled.

It seems clear that students of different ages have different perceptions of statements related to "causes" and "solutions" of environmental problems. This result has considerable implication to the nature of instruction most appropriate for students at different grade levels.

A STUDY OF THE EFFECT OF SCIENCE KNOWLEDGE AND COPING STRATEGIES RELATED TO STRESS ON STUDENT BEHAVIOR

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A perusal of recent lists of non-fiction best selling books leads one to believe that consumers of Western culture are preoccupied with how to cope with the stresses imposed by said culture. However, the schools, designated agents of enculturation, are currently in a position where accountability for basic skills may interfere with organized curricular efforts aimed at teaching students basic coping mechanisms. While strength in academic achievement and development of emotional maturity need not be mutually exclusive goals, the blend of the two areas requires efficient allocation of time and funds and proof that a "coping curriculum" works. The fact that such an effort is worthwhile was recognized early in the century when the National Education Association (1918) published its "Cardinal Principles of Secondary Education," and thereby endorsed a harmony between the cognitive and affective domains within the school setting.

The fact that there are physiological and biochemical correlates of emotional stress brings the challenge of the "coping curriculum" into the realm of science teaching. That the physiologic and subjective processes of the body can indeed be regulated by the individual is a major contention of biofeedback researchers. Brown (1974) holds that this regulation of body processes is enhanced if the individual has a certain amount of scientific information about the processes. Psychologists have found that specific kinds of stress (e.g., test anxiety) can be alleviated through application of the principle of "informational learning." Richardson (1973) has evidence that an individual is able to change his behavior in a desired direction if he is given accurate and useful information about the task or problem with which he is trying to cope.

The research strategy in this study is of the engineering or systems design genre with an empirical emphasis, according to the terminology of Butts (1971). The study had two major emphases. The first entailed the design and formative evaluation of a two-week minicourse dealing with the biochemical, physiological, and psychological aspects of emotional stress. The second involved the effects of two treatments on student anxiety levels.

The subjects were 431 secondary school biology students in a central Texas school district; they were enrolled in four schools in classes of six teachers. Treatment A consisted of the minicourse and a four-day session on coping with test anxiety. Treatment B consisted of only the coping treatment. The treatment and control groups were pretested on the A—State Scale of the State-Trait Anxiety Inventory (Spielberger, 1968) and on the Test Anxiety Scale (Sarason, 1972) prior to a class test, and on the minicourse achievement test. The same instruments were given as posttests.

Analysis of covariance and linear models were used to differentiate anxiety and knowledge levels among groups. Significant differences were found in knowledge but not in anxiety levels. Follow-up work is currently in progress in northern Florida to refine the course and to differentiate anxiety levels.

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CONCURRENT SESSION A

Session A-3 Teacher Characteristics

Presiding:
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Development and Validation of An Instrument to Assess Teachers' Conceptions of Scientific Theories

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The Effects of Knowledge on Elementary Science Inquiry Teaching

Daniel C. Dobey
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Conceptions of Heat-Related Phenomena Held By Prospective Elementary School Teachers

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DEVELOPMENT AND VALIDATION OF AN INSTRUMENT TO ASSESS TEACHERS' CONCEPTIONS OF SCIENTIFIC THEORIES

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Objectives and Rationale

The objective of the research was to develop and validate an instrument to determine teachers' conceptions of particular aspects of scientific theories. The following desiderata guided development of this instrument:

1. Joseph Schwab has claimed that understanding the tentative and revisionary characteristics of scientific knowledge is an important educational goal because of its implications for the public's understanding and support of the scientific enterprise. A need exists for an instrument to assess teachers' understanding of this view of science.

2. Instruments that attempt to describe students conceptions of science should be sensitive to the variety of interpretations that may be legitimately ascribed to aspects of the nature of science.

3. Instruments designed to measure understanding of aspects of the nature of science should be organized around sufficiently specific aspects so that scores may be interpreted explicitly in terms of the specified domains.

Procedures for Instrument Development

The tentative and revisionary view of science may be expressed in terms of particular aspects of scientific theories. The following five categories of understanding were postulated as being useful in describing conceptions in the nature of science: 1) characteristics of theories, 2) ontological significance of theories, 3) testing of theories, 4) theory preference, and 5) generation of theories. These categories were described in terms of two alternative views concerning the philosophic issues represented by the categories. Likert scaled items were then generated that could be used to discriminate between the alternative conceptions of each category. A tentative and revisionary conception of science was inferred from a particular set of alternative views of these categories. To facilitate determination of the possible subject-matter dependence of understanding of the categories, items were placed in the following five contexts: 1) Bohr's theory of the atom, 2) Darwin's theory of evolution, 3) the theory of plate tectonics, 4) theories of abiogenesis, and 5) subject-matter independent items.

Eighty items were generated and administered to 56 elementary education majors at Michigan State University. Category reliabilities (KR_{20}) and item-category correlations were used to select 40 items that were used in the final form of the instrument.

Procedures for Instrument Evaluation

The multi-trait and multi-method matrix of Campbell and Fiske was used to provide information concerning the validity of the categories. Category and total test reliabilities were determined using the KR_{20} measure of internal consistency.

Application

1. Present

   The instrument was applied to three different populations at Michigan State University: elementary-education majors, chemistry students, and philosophy students. The different performances of these populations will be described and the results interpreted in terms of their implications for the validity of this instrument.

2. Future

   Although the data obtained have some immediate implications, the primary contribution of this study is in making available a valid and reliable instrument with some of the following potential uses:

   a. Determining teachers' understanding of the tentative and revisionary characteristics of scientific knowledge

   b. Discriminating teachers' conceptions of particular aspects of scientific theories

   c. Assessing student outcomes in educational programs whose goal is to teach a particular conception of the nature of science.

THE EFFECTS OF KNOWLEDGE ON ELEMENTARY SCIENCE INQUIRY TEACHING

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Throughout the evolution of the United States system of education, knowledge of science, or science content has always been the sine qua non of science teaching. Recently, however, the question arises, does science background knowledge help or hinder the science inquiry teacher? Since the idea of an inquiry approach to instruction has spread to school districts across the country, the effect of teachers' knowledge on their subsequent inquiry teaching behaviors is an important consideration.

The purpose of this study was to examine the effects of three different amounts of science content knowledge on teacher inquiry teaching behaviors (and the subsequent student behaviors). The Instrument for the Analysis of Science Teaching, Version 2 (IAST, v. 2) (Hall, 1972), an adaptation of Flanders Interaction Analysis System, was used to quantify classroom behaviors. Upon analysis of video-taped lessons, the following major research question was addressed:

> Is there a relationship between the level of science knowledge and the level of inquiry teaching?

The word inquiry has played an important role in the language of science education, but widespread confusion over the meaning of the term has been a major problem. The ambiguity of the word creates problems not only for classroom teachers but also for science educators.

Level of inquiry teaching was operationally defined by quantitatively assessing teaching behaviors via the IAST, v. 2. Higher levels of inquiry teaching were associated with those teachers who scored significantly higher (group mean scores from IAST, v. 2 data) on:

1. general teaching indirectiveness (I/D ratio)
2. teacher receptivity of student responses (revised I/D ratio)
3. the extent to which divergent questions are used compared to convergent questions
4. the amount of student nonverbal activity
5. the amount of peer (student) interaction
6. teacher flexibility (Flexibility Factor and Flexibility Ratio)

and significantly lower on:

7. the ratio of teacher talk to student talk
8. the percentage of continuous teacher lecture

The sample consisted of approximately 25 preservice elementary teachers completing the sequence of elementary science methods courses at Syracuse University. Upon successful completion of the elementary science methods course, "Elementary Science Inquiry Teaching," each of the subjects was required to teach an inquiry lesson on pendulums to two fifth grade children. The pendulum topic, from the inquiry oriented Elementary Science Study curriculum (1969), was chosen because it can provide children (and teachers) with many questions and constant activity. Three different levels of pendulum knowledge were given to teachers prior to their teaching the lesson: a Knowledge group (K), an Intermediate Knowledge group (IK), and a No Knowledge group (NK). A knowledge pretest allowed categorization of individuals into one of the three knowledge groups. A knowledge posttest insured that teachers did or did not have knowledge about pendulums, depending on which level they were assigned to.

This study focuses on how specific science background knowledge influences elementary teacher inquiry teaching behaviors. Results indicate that science knowledge does not significantly affect the level of inquiry teaching. That is, no matter what amount of science background knowledge teachers possess, their level of inquiry teaching does not significantly differ.

This study may indicate that more instructional time needs to be spent educating teachers how to use the knowledge they have rather than adding more knowledge through content courses or spending time on other teacher preparation topics. Teachers also need to probe their students concerning understanding of concepts. Too often it was found that teachers closed a particular part of a lesson and went on to another concept because they "felt" that the students understood. Further probing by teachers is necessary to substantiate this "feeling."

As more and more science educators and teachers advocate inquiry techniques, the problem of how inquiry and content mesh for effective science teaching must be investigated. The ultimate goal is to help inform teachers how to cope more effectively in the science inquiry setting.

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CONCEPTIONS OF HEAT-RELATED PHENOMENA HELD BY PROSPECTIVE ELEMENTARY SCHOOL TEACHERS

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The way in which teachers conceptualize a particular content area may influence:

1. their ability to assimilate meaningfully subsequent related information (Ausubel, 1968), and

2. their ability to teach the content as a coherent and meaningfully related set of concepts.

This study involved a detailed investigation of the conceptions held by prospective elementary school teachers relative to a particular science content area, and a consideration of how these conceptions might influence future learning and teaching.

It was felt that a detailed analysis of the logical relationships between concepts in a particular content area, coupled with indepth clinical interviews of students to determine their conceptions of these relationships, would provide information relative to concept formation that is difficult if not impossible to obtain through the use of objective instruments. For example, in clinical interviews explanations given by students are less likely to be influenced by "hints" which are difficult to remove from the questions and alternative choices characteristic of objective tests.

The content area chosen for investigation was one that is fundamental to a wide range of phenomena in the physical sciences—the molecular model and its application in explaining the general properties of solids, liquids, and gases. A detailed content analysis was carried out to establish relationships within the molecular model that underlie

1. the basic differences between gases, liquids and solids;
2. changes of state;
3. heat and temperature; and
4. heat transfer.

This analysis utilized techniques derived from information processing and cognitive psychology such as those described by Gregg and Greeno (Klahr, 1976).

This content structure provided a guide in the development of interview protocols to be used individually with a sample of preservice elementary teachers enrolled as students in a course in physical science. In most cases, students were asked to explain a phenomenon demonstrated to them using actual physical apparatus. To encourage them to think about the mechanisms causing the effects presented to them, an attempt was made to select specific demonstrations which were unfamiliar to most students in the population. For example, a partially inflated balloon was placed inside a bell jar from which air was gradually extracted. As the balloon began to expand, students were asked to describe their observations and provide an explanation for the effect. The interviewer then probed the students to determine their deepest level of understanding, taking care to avoid providing hints which might suggest a molecular explanation. Interviews were also audio-taped for later analysis.

By listening to the audio-tapes, a "concept map" was constructed to reflect the conceptual organization possessed by each student relative to the "content map" that had been prepared in advance from the content analysis. The validity and reliability of these maps were assessed by analyzing the degree of agreement among several science educators.

An initial set of protocols were developed and administered prior to instruction in the four areas specified above. Students were then provided instruction in these areas and in each case a molecular model was developed. A second series of protocols involving the same kinds of phenomena, yet using different demonstrations, was developed and interviews carried out with the same students to assess the degree to which the instruction was effective in teaching the general aspects of the molecular model.

In addition to the protocols, a background questionnaire was administered to obtain data such as prior science courses taken, grade aspirations, learning styles, attitudes toward science, and tendencies toward rote learning. An objective post-test was also utilized.

Analysis was carried out to assess the degree to which each of these background variables was related to the students' prior conceptions of the content, and how this in turn influenced their ability to assimilate meaningfully the concepts provided during instruction. The results of this analysis will be discussed, including our perceptions of the utility of content and concept maps, protocols, and clinical interviews in assessing cognitive structure.

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CONCURRENT SESSION A

Session A-4 Paper Set: Cognitive Science Methodologies

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Research Methodology for Representing the Strategies Sixth Grade Children Use in Finding Relations Between Variables

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Long-Term Retention of Cognitive Strategies: Method and Results

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Content Analysis Using Cognitive Science Techniques

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RESEARCH METHODOLOGY FOR REPRESENTING THE STRATEGIES SIXTH GRADE CHILDREN USE IN FINDING RELATIONS BETWEEN VARIABLES

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Objective

The purpose of the study on which this paper is based was (a) to identify strategies sixth grade children use in finding relations between variables given the following task:

Given:	A set of elements
	An observation/measurement procedure for the dependent variable
Required:	A rule relating two variables that hold true for the given elements

and (b) to determine whether a strategy or elements of a strategy are used consistently by a child when presented with three parallel problems involving the same task over different content.

This paper focuses on the research methodology used to gather information about the strategies sixth grade children use in finding relations between variables, and the procedures for representing this type of student knowledge.

Methods and Data Sources

The subjects were chosen from sixth grade classrooms in which the Science Curriculum Improvement Study (SCIS) program was being taught. A sample who would successfully perform the tasks and provide a rich verbal protocol was desired, although gifted children were avoided. Six children were selected on the basis of their performance on a screening instrument and on their teacher's assessment of their verbal fluency.

The children were presented a practice problem, the three problems of interest (rods, wheels, and wires), and two modified Piagetian tasks (combining variables and controlling variables). The child's performance on each problem was videotaped while the child was doing the activity. Immediately after the child completed an activity, s/he reviewed the videotape with the experimenter and was asked to recall any thoughts or feelings which occurred while doing the activity. The experimenter assisted the child in this recall by asking probing questions. This interaction was recorded on audiotapes. To this experimenter's knowledge, this "stimulated recall" technique has not been used with children before.

The videotapes and audiotapes were transcribed verbatim to become the data source. Inferences about the child's processing were made, first, on the basis of the videotape alone, then, in combination with the stimulated recall audiotape. Flowchart models for each problem performance were created. Finally, a "best fit" model, a model that attempts to describe the subject as accurately as possible in a generalized form, was constructed. Predictions about how the subject would perform on the modified Piagetian tasks were made, based on their performance on the three problems.

Results and Conclusions

The findings regarding the procedures which will be reported were:

1. The "stimulated recall" technique provided a rich data base for developing models of the students' strategies. In fact, the procedure was essential for inferring the strategies used by several of the students.

2. The method of analyzing the data sources and of representing strategies in flow chart form was reliable.

3. Research on children's strategies appears to be viable and worthwhile. For example, three types of students' strategies were identified. In addition, it was possible to identify some effects of prior student knowledge on the rules they used during the task, but not on the strategies used in finding those rules.

LONG-TERM RETENTION OF COGNITIVE STRATEGIES:
METHOD AND RESULTS

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Rationale and Objectives

A detailed model of the content of instruction is a necessary prerequisite to the assessment of what students know following instruction. The model of the instructional content becomes the standard by which learning and retention are judged. Recently, researchers in cognitive science have distinguished between conceptual and procedural knowledge. The latter is a cognitive strategy which is a sequence of cognitive processes and decisions sufficient for performing a specified task. The purposes of this paper are to report the methodology for describing students procedural knowledge and to report on the long-term retention of such knowledge. The procedures included the modeling of cognitive strategies as flow charts and the calculations of strategy scores based on the models which were used to describe student behavior. The results are related to (1) changes in student use of a learned strategy over a three-month interval and (2) differences between the strategy performance of students instructed in the complete strategy and students instructed in using subroutines of the strategy as well as the complete strategy.

Methodology

The purpose of the instruction was to teach students to classify igneous rocks. The classification scheme consisted of nine classes. Grain size and the proportion of light colored minerals were the two relevant variables. A cognitive strategy was developed for the task and represented as a flow chart. The strategy involved the comparison of samples to standards which delineated the boundary of each class and the verbal report of value labels, such as large grains, for the row and column in which the sample was placed. The instructional protocols, the system for recording data, and scoring programs were based on the strategy model.

Forty-eight fourth grade students were randomly assigned to one of two treatment groups (n's = 24). One group was given instruction in task specific cognitive strategies for the final classification task. The second group was given instruction on subroutines of the complete strategy in addition to instruction on the complete strategy. Both groups were given a posttest one day after instruction and again three months after instruction. Several computer generated scores were used to describe the extent to which students used the complete strategy and a strategy components during the two tests. Comparisons between groups were done using Student's t-statistics.

Results and Conclusions

The methodology employed resulted in detailed descriptions of student performance. Without a description of the content of instruction, in this case, task specific strategies, it would not have been possible to obtain some of the following results.

Students in both groups learned the complete strategy during instruction, but did not use the complete strategy extensively on the posttest. Instead they used components of the taught strategy to construct their own idiosyncratic strategies. Students consistently reported the value labels more frequently than they compared samples to standards. During the long-term retention test there was a large decrease in the reporting of a verbal response, but only a moderate decrease in the comparison of samples to standards. No significant differences between groups in strategy and strategy component scores were evident.

CONTENT ANALYSIS USING COGNITIVE SCIENCE TECHNIQUES

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There are several educationally significant justifications for doing content analyses that lead to propositional representations of the structure of the knowledge in the content segment being analyzed. From a curriculum viewpoint, content analysis can serve as the basis for selecting cognitive intended learning outcomes (Johnson, 1977). Cognitive competencies (what students are expected to do with the knowledge learned) can be more systematically identified after having identified what knowledge elements are to be learned. From a research standpoint, an important reason for analyzing content (instructional content) is to be able to compare what students know with what they are to be or have been taught. Therefore, it must be possible to represent the results of education-related content analyses in a form comparable to cognitive structure representations. Various methods have been devised by educational researchers for analyzing and representing subject matter knowledge. One group of these techniques (syntactic techniques) will be critiqued briefly in this paper.

The intent of this paper will be to describe a method of "semantic" content analysis by using an example from Mendelian genetics. The paper will describe both the method of analysis and a technique for representing, in semantic form, the results of the analysis. The paper will describe the use of the representational techniques (semantic and active structural networks) and symbols of Lindsay and Norman (1977) and Norman and Rumelhart (1975). Their techniques have been modified, however, with ideas dealing with schema theory taken from Rumelhart and Ortony (1977) and Norman and Bobrow (1976).

This paper will demonstrate a procedure while tying the procedure to theories of knowledge representation. Extensive use of diagrams will follow the step-by-step development of the content analysis into its final representational form which includes schemata for a variety of Mendelian genetics concepts.

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CONCURRENT SESSION A

Session A-5 Piagetian Research

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A Method of Scoring Piaget's Shadows Task

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The Effect of Small Group Teaching on Acquisition and Transfer of Nonvisual Seriation Abilities

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The Effect of a Weighted Scoring System on the Construct Validity of the Piagetian Logical Operations Test

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A METHOD OF SCORING PIAGET'S SHADOWS TASK

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We present a method of scoring the shadows task (Inhelder and Piaget, 1958) which enables the experimenter to assign numerical value to the types of responses the subject makes in reply to the experimenter's questions. The ability to translate the shadows task into a numerical score is important because it enables the task to be included in statistical analysis with other tests or measures of ability which have numerical scores. It also simplifies the scoring process and thus should increase its use in science education research.

Our scoring system consists of three sections. The first is a familiarization section which requires six predictive responses about shadow size. A maximum score of six is possible. The second part of the familiarization section consists of five possible points; one for measuring from the screen and one each for both the correct placement of the rings involving a 1:2 and 1:3 ratio and the correct explanation of the strategy used for placement.

The objective section consists of 18 possible points consisting of three predictions each of placement of the rings for the ratios 3:6, 4:6, 2:6, 2:4, 2:5, 3:5.

Section three consists of generalizability questions scored on a seven-point scale based on the amount of generalization from the task required to answer the question correctly.

The system was tested by administering the shadows task to 36 students in an introductory physics course. As the task was given it was scored by the experimenter and an observer.

They then compared their scores and reached consensus as to the score to be assigned to each section. The task was again scored by a third individual who did not observe the task as it was given and based his judgment solely on the score sheets. Perfect agreement occurred on 77.8 percent of the subjects' sheets when scored by the experimenter/observer and a third party. A one-point difference in score was observed in 8.4 percent of the cases, a two-point difference in 5.6 percent of the cases, a three-point difference in 5.6 percent of the cases and a four-point difference in score out of a total of 38 points in the remainder (2.8 percent).

This method shows a high degree of consistency between the experimenter/observer scoring and that of a third party, indicating that the method of assigning numerical scores to verbal responses is simple and uniform even when the scorer did not observe the task. The system also enables the task to be broken down into component parts with separate scores which can be analyzed individually or can function as a single score when added together. This score provides a method whereby a clinical measure of ability can be analyzed along with paper and pencil measures of ability.

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THE EFFECT OF SMALL GROUP TEACHING ON ACQUISITION AND TRANSFER OF NONVISUAL SERIATION ABILITIES

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Rationale and Objectives

Several elementary school science programs (both federally and commercially supported) have included seriation tasks as a prominent expectation or goal of early childhood learning. Yet little (with two exceptions) practical research beyond Piaget's developmental descriptions and stage placements has been reported for this task. Schafer (1975) reported that individual training using corrective feedback, attention to task stimuli and other instructional methodologies produced substantial and durable seriation behavior changes. Padilla (1975) reported that first grade children, when individually taught, can learn strategies for seriation tasks that increase seriation abilities to operational levels. The purposes of this experimental study were (1) to determine if small group methods would prove successful in teaching seriation abilities; (2) to investigate the teaching and transfer of seriation abilities using three distinct treatments; and (3) to investigate the relationship between visual and nonvisual seriation abilities.

Methodology and Design

One hundred and twenty first grade children were administered Piaget's stick seriation task and then classified as either stage I (nonseriators), stage II (some operational abilities) or stage III (operational seriators). Twenty-four children from each stage were randomly chosen and randomly assigned to one of three treatment groups. Each treatment group was further divided into subgroups of six children who received their treatment together. The treatments are as follows:

> Treatment One children were taught to choose the extreme (heaviest or roughest) object from among a group of objects, and then to place it to start an ordered row. Then the next extreme object, from among those remaining, was chosen and placed next in the row. This process was repeated until all objects had been ordered.
>
> Treatment Two children were not taught a specific method for ordering, but rather were allowed to discover and develop their own strategies for task completion. They were given oral task directions, models of ordered objects and feedback on task accuracy.

> Treatment Three children were given no method for ordering, no directions to order, and no task feedback. Instead, they were urged to manipulate the materials in their own creative ways and to discover relationships among the objects as they worked.

Each treatment group experienced four training sessions over a two-week period, using the following sets of materials. These same materials were used in post and retention testing as a measure of direct learning.

> The weights were a set of eight cups ranging in mass (10 to 2100 gm). They were used for ordering on mass.

> The feelies were a set of eight cups with materials of varying texture (smooth acetate to 40 grit sandpaper) glued to the inside surface. They were used for ordering on texture.

During post and retention testing, a third set of nonvisual materials, the pull toys, was used to measure transfer.

> The pull toys were a set of eight pipes with handles which took a varying amount of force (.8 to 11.25 lbs.) to pull. They were used for ordering on force.

Each of the above sets of materials differed only on the variable of interest.

Instruments and Data

Individual posttests consisting of one attempt to order the weights, the texture cups, the pull toys and the sticks used on the pretest were administered. This test was repeated as a retention test three months later. For each task a Kendall's Tau correlation Task Score was computed to judge the degree of accuracy. A two-way ANOVA was performed on the post and retention tasks. Treatment group and stage were the independent variables and the task score was the dependent variable.

Results and Conclusions

Posttest ANOVA results and post hoc analysis showed treatments one and two to be significantly better than treatment three ($p \leq .05$) on the direct learning tasks. A significant interaction effect and subsequent graphing indicated that treatment one was significantly better for stage I children than were treatments two and three. On the transfer task treatment one again proved significantly better than treatment three ($p \leq .10$) but no interaction effect was apparent.

Retention test ANOVA and post hoc analysis showed that the direct learning and transfer results remained stable over time for all groups but two. While treatment two stage I children improved on both direct learning and transfer of learning tasks, treatment one stage I children dropped slightly on the two tasks.

These results along with the extremely high (approaching perfect on posttests) task results of children experiencing treatments one and two indicate that practical, transferable, small group instruction can prove as successful as individual teaching methods if an appropriate teaching methodology is used.

Comparison of pretest, posttest and retention test stick task results showed increased and durable abilities on the latter two tests for more stage I and II children than one would expect by maturation alone. This occurred regardless of treatment. Further analysis and testing is necessary to fully explicate this phenomenon, but it appears probable that the testing and training experience with the nonvisual materials had a positive transfer effect on this Piaget task. This implies that certain specific seriation experiences might be critical for the most efficient mastery of the underlying aspects of seriation.

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THE EFFECT OF A WEIGHTED SCORING SYSTEM ON THE CONSTRUCT VALIDITY OF THE PIAGETIAN LOGICAL OPERATIONS TEST

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The goal of this study was the investigation of weighted scoring procedures for the Piagetian Logical Operations Test (PLOT), a group administered measure of four aspects of Piaget's formal thought. Specifically, the investigators posed the question: Does a scoring procedure in which increased weight is given to questions that assess reasons for cognitive decisions provide more support for the construct validity of PLOT than a scoring procedure which weights all questions equally?

Eighty-four students in grades 10-12 of a south central Indiana consolidated school corporation participated in the study. Subjects were randomly selected and assigned membership in one of two equal sized groups having the same number of males and females from each grade. Data obtained by clinical interview, PLOT, and intelligence test records were analyzed using a 2x3x2 factorial design. Subjects in group one received five clinical interviews followed by PLOT while subjects in group two were administered the instruments in reverse order. A Campbell and Fiske multitrait-multimethod matrix consisting of three methods and four traits, factor analysis, and three-way ANOVA were used to statistically examine the data.

Findings and conclusions concerning the reliability and construct validity of PLOT are set forth and discussed together with implications for use of PLOT in science education research and science instruction.

CONCURRENT SESSION B

Session B-1 Paper Set: Predictors of Science and Mathematics Achievement and Science Career Expectations of Innercity Adolescents

Presiding: Nancy Roberts
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Theoretical and Experiential Foundations of the Project City Science Research Program

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Science Career Expectations of Black, Innercity Students

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Selected Cognitive and Affective Correlates of Mathematics and Science Achievement

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Selected Affective and Cognitive Predictors of Science Career Expectations

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THEORETICAL AND EXPERIENTIAL FOUNDATIONS OF THE PROJECT CITY SCIENCE RESEARCH PROGRAM

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For the past five years, Project City Science has been operating to improve science teaching in middle schools in the heart of New York City. Emphasis has been placed upon an enriched, experiential, "hands-on" approach to teaching applied through an intensive in-school training program. This program has been for preservice teachers as well as a supervisory program for doctoral students.

Numerous questions have arisen as a result of our experience in the schools regarding the achievement and career interests of inner-city adolescents. Thus, the developing research program of Project City Science has become focused on the correlates of science and math achievement as well as of science career expectations.

The studies reported in this paper set are the beginning of a long-term research effort intended to explain more clearly the achievement and science career expectations of inner-city middle school students. Hopefully, this will lead to more explicit strategies for possible interventions related to scientific careers.

SCIENCE CAREER EXPECTATIONS OF BLACK, INNERCITY STUDENTS

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Introduction

This research provides a partial description of innercity early adolescents' perceptions of science and scientists and their career expectations in science-related fields.

A structured questionnaire was administered by science teachers to 563 eighth grade science students from one predominantly black New York innercity school. This questionnaire was designed primarily as a survey to tap a diverse set of science-related perceptions.

Questionnaire Format

The questionnaire was constructed with several item-types. The first eight items, designed in the Likert format, are intended to measure science career expectations. The second set of multiple-choice items asked for such information as reasons for becoming a scientist and whether or not one personally knew a scientist. From a third set of items, which lists 17 scientific occupations ranging from x-ray technician to experimental scientists, pupils were to identify those they considered to be scientists.

The next sets of items asked students to rank-order types of jobs they wished to pursue, both scientific and non-scientific. Finally, the last two items asked what activities pupils liked most in science class and whether or not their experiences in class affected their future science career plans.

Statistical Analysis

A Cronbach alpha coefficient was determined for the Likert subscale to measure reliability ($\alpha = 0.59$). Next a 2 x 5 factorial analysis of variance was performed on this subscale to examine both main effects of sex and ability level and interaction effects on science career expectation. Moreover, frequency distributions were tabulated for all item responses, and correlation analyses were performed to determine inter-correlations among items.

Results

The major findings were:

1. There was a significant sex effect ($F = 25.766$, $p \leq .001$), i.e., boys had greater science career expectations than

girls. There was no significant ability level effect (F = 1.409), but there was a significant interaction (F = 2.506, $p \leq .05$) between sex and level on science career expectations.

2. Students expressed a fairly "narrow" view of scientists. Persons such as finders of new cures and laboratory experimenters were perceived as scientists, while persons such as nurses and x-ray technicians generally were not. Moreover, there was no significant positive relationship between "broadness" of view and science career expectations.

3. Among the science occupations, medical doctor was ranked first, second, and third choice most frequently. Nursing was an almost unanimous first, second, or third choice for girls, while engineering fields were predominantly male choices. However, there was no significant positive relationship between these rankings and science career expectations.

4. Business was ranked most frequently as a first and second career choice, while science was fourth; however, a significant positive correlation ($r = .47$, $p \leq .001$) was found between science career expectation and frequency of ranking science as a first and second career choice.

Although all of these findings are generalizable only to this particular sample of innercity children, this questionnaire was useful in describing these students' perceptions of scientists and career aspirations in science. Perhaps the next step should be to revise the questionnaire so that it conforms to a single item-format. With further refinement, the questionnaire could be used in more controlled, experimental studies, where generalizability would be increased.

SELECTED COGNITIVE AND AFFECTIVE CORRELATES OF MATHEMATICS AND SCIENCE ACHIEVEMENT

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The purpose of the present study was to investigate the effects of global self-concept, academic self-concept, and need for academic competence on the science and mathematics achievement of inner-city adolescents. While global self-concept has been the focus of extensive research and intervention efforts, this variable alone has failed to account adequately for the variance in academic achievement. Based on the notion that situation-specific traits are superior to global traits as predictors of behavior, this study has included academic self-concept as an additional predictor. Furthermore, the effects of need for academic competence, a situation-specific index of motivation, were also assessed. Since these affective traits were measured via items presented in verbal format, the effects of verbal ability were assessed and partialled out of the other relations involved.

The sample involved in the present study consisted of 328 black eighth graders, 151 females and 177 males who were drawn from a New York City public junior high school. All research participants were characterized as coming from low socio-economic status backgrounds.

Four tests were administered to all participants: The Peabody Picture Vocabulary Test, Rosenberg's Self-Esteem Scale, The Self-Concept of Ability Scale, and the Need for Academic Competence Questionnaire. Grades in science and mathematics were used as the criterion measures.

Analyses were conducted separately for females and males in the two subject matter areas. Thus, four separate regressions were obtained. These regressions were derived through commonality procedures, which were necessitated by the substantial degree of intercorrelation which marked the independent variables.

Results of the study indicated that a combination of the four independent variables explained significant proportions of variance in both science and mathematics achievement for females as well as males. Sex differences in the predictions were as follows: A greater proportion of variance in science achievement was accounted for in the female as opposed to the male sample, when all four independent variables were used as predictors. When verbal ability was partialled out, the resulting explanations of variance in science achievement were no longer significantly different for the two sexes.

Critical changes in prediction as a result of partialling out verbal ability were even more pronounced when mathematics rather than science achievement was used as the criterion. While the variance in mathematics achievement accounted for by a combination of all four independent variables (verbal ability included) was not significantly different for males and females, the variance accounted for after partialling out verbal ability was significantly greater for males as opposed to females.

Throughout the study academic self-concept was superior to global self-concept as a predictor variable.

Results of this study suggest that future research and intervention programs must be much more attentive to sex differences in personality patterns related to achievement in science and mathematics. Furthermore, future efforts at enhancing achievement should focus on situation-specific aspects of self-concept and motivation rather than on global traits.

SELECTED AFFECTIVE AND COGNITIVE PREDICTORS OF SCIENCE CAREER EXPECTATIONS

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In the companion study the variables global and academic self-concept, need for competence and verbal ability were used to predict science and mathematics achievement. As an extension of this study, we addressed the question: What is the relationship between these predictors and science career expectations? To determine this relationship we will combine the data obtained from both the science career expectation and achievement studies. In this investigation the criterion variable will be science career expectations, as measured by the science career expectation subscale of the structured questionnaire. The predictor variables will be the same as those in the achievement study.

Of the 543 eighth grade science students used in the career expectation study, 284 students (142 males and 142 females) also participated in the achievement study. Hence, analyses will be performed on only these individuals.

Similar statistical techniques, i.e., multiple regression and commonality analyses will be applied to the data set. Moreover, these data will be analyzed separately by sex.

CONCURRENT SESSION B

Session B-2 Student Characteristics and Performance

Presiding: Bruce Tulloch
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The Mental Representation of Three-Dimensional Shape Conceptualized from Two-Dimensional Perspective Views by Sixth and Eighth Grade Students

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Field Dependence/Independence, Logic, Space Perception and Science Achievement

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Intellectual Achievement Responsibility, Spatial Ability, and Sex as Factors Influencing Performance in Regents Biology

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THE MENTAL REPRESENTATION OF THREE-DIMENSIONAL SHAPE CONCEPTUALIZED FROM TWO-DIMENSIONAL PERSPECTIVE VIEWS BY SIXTH AND EIGHTH GRADE STUDENTS

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Objectives and Rationale

The purpose of this study was to determine: (1) the effects of instructional method, grade level, and sex on the ability of students to mentally represent three-dimensional shape from two-dimensional depiction of perspective views; (2) whether the operation for performing this, learned in instruction, was transferable to novice shapes not encountered in instruction; and (3) what solution procedures were employed in performing a spatial relationship task of mental representation after instruction. The rationale for the study was that, since much of the secondary science instruction which may be encountered by students often involves two-dimensional depiction of three-dimensional entities, an understanding of how students' mental imagery transforms this into a mental representation of shape might be useful for instruction and curriculum materials.

Methodology and Design

Eight groups of male and female subjects were randomly selected from grades six and eight. Four groups within each grade level were randomly assigned to one of three instructional methods or a control setting. The instructional methods presented two days of instruction concerning two spatial relationship operations, but they differed in the visual mode used to depict these operations. The three modes were: (1) Shadow Projection; (2) Photographic Perspective; and (3) Geometric Sectioning. On the third day, 101 treatment subjects and 40 control subjects completed the dependent variable task of matching three-dimensional objects with two-dimensional shapes of perspective views. Twenty randomly selected subjects from the treatment groups were interviewed after the task concerning what solution procedures they employed.

Instruments and Data

A measure of the acquisition of the spatial relationship operation presented in instruction was taken on each of the two days of treatment. The dependent variable task, similar in format to these previous measures during treatment, involved shapes not presented in the instruction comprising treatment. The same interview schedule of five questions was presented to the 20 subjects.

Findings and Conclusions

The major findings were: (1) a significant difference for sex, with males performing at a higher level than females, was found in four contrasts of performance by male and female subjects; (2) four solution procedures were employed by treatment subjects, with only one corresponding to the test construct of the dependent variable instrument; (3) more eighth grade subjects were able to perform the spatial operation for mental representation of three-dimensional shape than sixth grade subjects; (4) 66 percent of all subjects correctly matched 13 or more of the 15 items on the dependent variable task; and (5) three-dimensional objects with similar shape were missed most frequently. The conclusions of the study were: (1) the dependent variable instrument did not measure solely the mental representation of three-dimensional shape; (2) males matched three-dimensional objects with sets of two-dimensional perspective views at a higher level of performance than females; and (3) some subjects in both grade levels were able to perform the spatial operation of mental representation taught in instruction in a transfer situation with objects not previously encountered in the instruction comprising treatment.

FIELD DEPENDENCE/INDEPENDENCE, LOGIC, SPACE PERCEPTION AND SCIENCE ACHIEVEMENT

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Problem

In theory, the ability to transform or restructure perceptual problem elements presented in a visual mode is predictive of a person's ability to solve a wide variety of cognitive tasks involving analysis and synthesis (Witkin, 1962/1974; Witkin and Goodenough, 1976).

Consistent with the restructuring model Wormack (1978a, 1978b) reported that high school and college students with high restructuring ability consistently attained significantly higher scores in science application and in overall science achievement than a person with low restructuring ability.

Since Thurstone (1944), Botzum (1951), and Yela (1949) reported common second order factor loadings of induction, deduction and space perception, referents of Witkin's field dependence/independence construct may overlap considerably with reasoning and spatial ability because of their common elements of restructuring. These measures were also expected to be predictive of science achievement.

This study was conducted to determine the underlying factor structure of logical ability, perceptual ability and selected science sub-skills. A parallel objective was to determine the contribution of field dependence/independence, logic, and spatial ability to the prediction of science achievement.

Procedures

Twenty-six male and 20 female college students participated in this study. The Group Embedded Figures Test (GEFT), Concealed Figures Test (CF-1), Locations Test (I-2), Inference Test (RL-3), Surface Development Test (VZ-3), and the Sequential Test of Education Progress in Science (STEP), Form 1A were administered to all persons during a group testing session. All scores for independent variables were the number right. Error scores were also included as additional independent variables in the analysis. The Step Test yielded a total raw score and separate sub-scores in science knowledge, comprehension, application, and higher abilities and achievement raw scores in biology, chemistry, physics and earth science.

All measures were submitted to an exploratory factor analysis with final rotation to orthogonal simple structure. Stepwise regression against science raw score total and separate science sub-skills was conducted with all independent measures in the analysis for the total sample and separately by sex.

Results

The factor analysis produced the following pattern of factor loadings:

Factor 1	Loaded all science sub-tests and RL-3.
Factor 2	Loaded CF-1, S-2, and VZ-3.
Factor 3	Loaded science knowledge, GEFT, RL-3, and VZ-3 error.
Factor 4	Loaded CF-1 and negative loadings of CF-1 and I-2 error.
Factor 5	Loaded S-2 and science knowledge and comprehension marginally.

Reasoning (RL-3), visualization (VZ-3), and space perception (S-2) accounted for 47 percent of the variability in science achievement. Among males, 60 percent of the variability in science achievement was attributed to RL-3, CF-1, VZ-3 error, CF-1 error, and RL-3 error. Among females, 88 percent of the variability in science achievement was attributed to VZ-3, RL-3, I-2 error, CF-1, CF-1 error, RL-3 error, S-2, and GEFT.

Discussion

If restructuring ability is viewed in its broader context to include measures of logical relations, visualization, space perception, and flexibility of closure, the data provide indirect support for Witkin (1962/1974), Witkin and Goodenough (1976), and Wormack (1978a, 1978b) who reported that restructuring ability was predictive of science achievement, and for Thurstone (1949), Botzum (1951), and Yela (1949) who reported common factorial association between measure of logic and space perception.

The results of this study may be useful to science educators and to educational researchers, providing a broader theoretical context for the prediction of individual differences in science achievement consistent with the degree of differentiation in logic, spatial ability, flexibility of closure and field dependence/independence.

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INTELLECTUAL ACHIEVEMENT RESPONSIBILITY, SPATIAL ABILITY, AND SEX AS FACTORS INFLUENCING PERFORMANCE IN REGENTS BIOLOGY

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Objectives and Rationale

Sex-related cognitive differences, whether their origins be psychological or sociological, are generally found to become increasingly apparent from grades 9 through 12, and have particular impact upon performance in science and mathematics. Spatial ability (Cognitive Style) and Intellectual Achievement Responsibility are two constructs which have been demonstrated to be particularly influential upon performance in science, and particularly sex-related. The objective of this study was to determine whether and to what extent the variables Spatial Ability (Cognitive Style), Intellectual Achievement Responsibility, Sex, and Performance were related among tenth grade students of Regents Biology in an urban school.

Sample and Measures

The sample consisted of 38 male and 34 female tenth grade Regents Biology students from an urban high school. The Group Embedded Figures Test (GEFT), and a modified form of the Intellectual Achievement Responsibility Questionnaire (IARQ) were administered to determine Spatial Ability/Cognitive Style (GEFT), internal responsibility for success (IAR+), internal responsibility for failure (IAR-), and total internalization of academic responsibility (IARQ). Performance was determined from scores attained upon two measures of concept attainment (derived from the N.Y.S. Regents Biology Exam) which focused upon structure and function in carbohydrates, lipids, and proteins (selected as the content area for relevancy to spatial ability).

Methodology and Design

GEFT and IARQ were administered one week prior to the learning sequence. The sixth day of the learning sequence was followed by the first measure of concept attainment. Following a review session on the eighth day, a second measure was obtained on the ninth day. The Chi-square statistic was used to determine whether and to what extent significant frequency distributions existed among the variables.

Results

GEFT: No sex differences in GEFT scores were found. However, Field-Independence (high GEFT group) was a significant predictor of Performance for males. There was no relation between Field-Independence and Performance for females.

IARQ: No significant interactions were found between IAR+, IAR-, and any other variable. IARQ and Sex interacted significantly, with males being significantly more internal than females.

Performance: The only significant interaction was that between GEFT and Performance for males. Inspection of the data indicated the possibility of a trend for males to outperform females.

Conclusions

Witkin (1977) has attributed differences in performance in science to the Cognitive Style/Spatial Ability construct of Field Independence-Dependence. Connor (1978) has shown how training in Spatial Ability can influence performance for females, and Koch (1977) has shown that Cognitive Style can be modified through training. This study indicates that the Cognitive Style/Spatial Ability construct is not a factor in performance for females at the tenth grade level in Regents Biology. Rowe (1974) has shown the significance of Locus of Control upon performance in science inquiry. This study did not find an interaction between Performance and Intellectual Achievement Responsibility, but did find a sex difference in the latter factor. The results of this study indicate that a more precise understanding of sex-related cognitive differences is necessary if the performance of females in science is to be improved.

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CONCURRENT SESSION B

Session B-3 Pre-service Teacher Education

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The Effects of Teacher Education Program Model on Preservice Teacher Behavior

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An Investigation of Three Approaches for Science Methods Instruction of Pre-service Elementary Teachers

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Achievement of Teaching Competencies by Secondary Science Teachers

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THE EFFECTS OF TEACHER EDUCATION PROGRAM MODEL ON PRESERVICE TEACHER BEHAVIOR

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Purpose and Rationale

The purpose of this study was to investigate the differential effects of field and non field-oriented models of science teacher education on preservice elementary teacher behavior. While some specific procedures of field experience have been investigated, the measured effects to date have failed to make clear the potential results of full-scale programs (Peck and Ticher, 1973).

This study attempted to analyze and relate the effects of type of full-scale program on specific goals set for elementary classroom teachers (Peck and Ticher, 1973; Pilz, 1974; Kahn and Weiss, 1973; McKinnon and Renner, 1971). These goals centered on the science teaching competence a preservice teacher can achieve as a result of methods courses and related public school experiences.

It was hypothesized that the program model type would differentially affect a preservice teacher's:

1. knowledge and performance in inquiry skills,
2. interest and attitude toward science in the elementary classroom,
3. perception and performance of role expectations and teaching behaviors in the teaching of science.

As a measure of goal success, the behaviors investigated by the instruments in the study were consistent with teaching roles involved in the instructional methodology of the "new" elementary science curricula. The new curricula from which behaviors were drawn are made up of selected science curriculum improvement projects developed over the last two decades, of which the Science Curriculum Improvement Study is an example.

Methodology and Design

The methodology involved longitudinal analysis of preservice teachers over a nine-month period including a science methods course and student teaching. Pre, post and postpost testing occurred over this period using paper and pencil tests, interviews and observational evaluation of science teaching behavior in an elementary classroom. The instruments used to measure each goal area have been reported as effective in the analysis of preservice teacher behavior (Sunal, 1978a, 1978b).

The sample consisted of 42 randomly selected preservice teachers from traditional and field-oriented programs offered at the same institution during the same time period.

The methods course experiences were matched in both groups with respect to emphasis, course content and coverage.

Results and Conclusions

Analysis of variance was used to measure significant change in the goal areas. Comparison of the two groups (21 traditional and 21 field-oriented), taking into account initial differences between the groups as determined in pre testing, was performed using analysis of variance. Results showed significant increases occurring in the goal areas at the end of the methods course and during student teaching as related to pretest levels. Comparing results of both groups, however, found significant differences occurring only in the level of teaching behavior.

The following conclusions were made: For the sample of preservice teachers involved in the study, the type of experience in elementary methods courses, traditional and field-oriented,

1. did not differentially affect a preservice teacher's knowledge and performance of inquiry skills
2. did not differentially affect a preservice teacher's interest or attitude toward science in an elementary classroom.
3. did affect a preservice teacher's performance of role behaviors in the teaching of science at the end of the methods course. Field experiences increase the amount and quality of performance of model role behaviors. No difference, was noted in student teacher perceptions of role behaviors in teaching science one semester later.

The results of the full-scale program study indicate that a field-oriented teacher education program cannot be assumed to be more effective in preparing teachers of science than a traditional campus program. Interaction among the program variables may be as effective in shaping behavior as substantially greater amounts of time, resources, observation and practice. The major comparison difference favoring the field program, the ability to more adequately model specific science teaching roles, is an important result with many implications.

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AN INVESTIGATION OF THREE APPROACHES FOR SCIENCE METHODS INSTRUCTION OF PRE-SERVICE ELEMENTARY TEACHERS

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Attitudes and beliefs about education and teaching have been shown by many researchers to affect teaching styles and teaching behaviors. An early study by Sprinthill, Whitley, and Moses (1966) found that cognitive flexibility which is an attitude and effective teaching which is a behavior were related. Additionally, Gough, Durflinger, and Hill (1968) showed that under certain conditions attitude measures predict behavior fairly well. Yager (1966) also emphasized that a teacher's attitude has an effect on the degree of content achievement, growth of critical thinking skills, and students' attitude toward a given course in science. Thus attitudes, beliefs, and values determine characteristic ways an instructor teaches classes and can have important consequences for students' learning, satisfaction, and development.

However, although the relative role of the teacher and student and the purpose of teaching and learning are defined, each teacher fulfills this role in different manners. Research on teaching styles in science has failed to show one method of instruction superior to all other methods. Victor (1978) has stated that no single strategy can be used to teach all aspects of elementary science. The strategy or combination of strategies that lends itself best to the effective learning of a particular process skill, concept, or conceptual scheme is the "best." Bush (1954) similarly presented data to show that no teacher or method was effective with all pupils. Horak (1976) has presented evidence to show that there are different science teacher types and Cunningham (1975) has shown the existence of four teacher types which were shown to be not equally effective with all types of students.

Since attitudes and beliefs about teaching change slowly, it may be conjectured that pre-service teachers would be most interested and show most enthusiasm toward implementing science instructional programs that are most congruent with their beliefs. The purpose of this study was consequently to determine if alternative modes of science methods instruction differentially affect pre-service elementary teachers (1) beliefs about science teaching, (2) general attitudes toward teaching, and (3) beliefs about the relative importance of specific teacher behaviors.

Subjects for this study were 90 students enrolled in three alternative science methods courses. One course was taught in an open classroom mode where field experiences in selected team taught open classroom settings accounted for over half of the instructional time. One course was taught in a self contained classroom mode where observations and teaching activities were planned in one-teacher classrooms and accounted for about a fourth of the instructional time. The third course was the traditional on campus science methods course which utilized very few instructional field experiences.

The instruments utilized in this study were the PMT Questionnaire (Wiggins, 1973) a science teaching affective attitude instrument similar to that reported by Good (1971), and a Science Behavior Classroom Q-Sort (Horak, 1976). The first two instruments were administered as pre and post tests and the third one was administered as only a post test. The pre-post data was analyzed utilizing analysis of variance procedures and the Q-sort data factor analysis procedures.

The overall analysis revealed that the students in the different courses did exhibit significantly different attitudes and beliefs about teaching science ($p \leq .05$). Students in the open classroom section consistently ranked items about student structure higher than did students in the other sections and also had a preference for the ESS materials. Guided discovery and rational inquiry models of instruction appeared to be the most useful for on campus students, while students in the self contained section chose to use total unit instruction based on textbook selected conceptual schemes or SCIS materials. These findings are important since they indicate that varying teaching approaches are most similar to the beliefs of the different groups of students and thus will probably be the ones that are most effective for each group.

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ACHIEVEMENT OF TEACHING COMPETENCIES BY SECONDARY SCIENCE TEACHERS

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Problem and Rationale

Competency based teacher training is conducted at many institutions. A critical part of a competency based program is the assessment of teachers to see if they have achieved competencies. The assessment can be used in a formative sense to advise instructors and students about progress and in a summative sense to certify that competencies have been achieved. Assessment data can also be used to assess program effectiveness. The purpose of this paper is to describe a competency assessment system and to report on the level of skill shown by a group of science teachers at the end of their training.

Methodology and Design

Seventeen competencies to be assessed were identified in a previous study involving more than 5000 respondents. Assessment instruments directed at these competencies were constructed, tried out, and revised over the course of a 10-month field trial. Nearly 1500 teachers and student teachers were assessed during 1977-78 as part of statewide piloting to establish reliability and validity.

Data describing 18 preservice teachers were compiled to construct a composite profile as a component of program evaluation. The preservice student teachers in science were assessed in the spring of 1978 near the end of a 10-week student teaching term. The assessment instruments were completed by the classroom teacher with whom they were working, by the university supervisor, and by another science teacher in the same school system but from a different building.

Instruments and Data

The instrument for assessing the 17 competencies requires examination of a teacher's plans and materials and observation of classroom procedures, and interpersonal skills. Competencies in each area are measured by using indicators for each competency (a total of 56 indicators for the 17 competencies). Behavioral descriptors define five levels of skill for each indicator. For each indicator a descriptor is chosen which is most characteristic of the plans on teaching performance. A competency score is the mean of the appropriate indicator score. Separate ratings are provided by the college supervisor, the classroom supervisor, and an external trained assessor.

Results and Conclusions

Data have been collected to support both the validity and reliability of the assessment. Multiple observers simultaneously assessing the same plans or observing the same lesson via videotape have high agreement when rating a teacher's performance. Reliability coefficients obtained under these conditions have ranged from 0.70 to 0.90. Factor analysis has been used to judge the cohesiveness of the indicators for each competency. Further validity estimates have been made by correlating pupil achievement scores with the competency level of teachers. Significant positive correlations of pupil achievement with teacher competence (ranging from .29 to .50) have been found for each of the 17 competencies.

The mean achievement score for the 18 teachers exceeded the minimum acceptable score for 16 of the 17 competencies. The highest scores were obtained on the four competencies associated with interpersonal skills. There were ten teachers who failed to demonstrate acceptable achievement of at least one competency. One poorest performing teacher received unsatisfactory scores in 5 of the 17 competencies.

Implications

The competency assessment system described here has been shown to have satisfactory reliability and validity characteristics. It can be used in preservice or inservice teacher training as a way to monitor individual teacher accomplishment of competencies, in program evaluation when results from all teachers are considered together, and in research studies of teaching skill.

CONCURRENT SESSION B

Session B-4 Symposium: Operations Research Models

Presiding: R. D. Sherwood
Education 202
Indiana University
Bloomington IN 47405

Operations Research Models for Quantifying the Structure of Behavior Sequences

Members: Gene Moser, David W. Kopp and Michael D. Duffy
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OPERATIONS RESEARCH MODELS FOR QUANTIFYING THE STRUCTURE OF BEHAVIOR SEQUENCES

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Are there quantitative models of behavior sequences which improve the characterizations of traits of learning? A review of research reported by science education researchers indicated that they have ignored applications of modeling and simulation techniques in their investigations. The purpose of this session is to present an overview of General Systems Theory models (Gagliano and Langseth, 1977) and demonstrate how they may be applied to interpret behavior sequence data. The participants will analyze each of four models for their validity in simulating behavior structure and discuss how science education researchers may adapt the models for their own investigations. Practical applications to real data will be displayed as examples of model and simulation analyses. Computer programs useful in developing models will be presented in the session.

The following models will be discussed by participants of the session.

1. Catastrophe Theory. Thom's model (1975) is valuable in defining whether or not sequences of behavior are discontinuous or continuous and what domains of sequences may exist in the structures of behavior. Functions of the morphics of five elementary catastrophe forms, in terms of fold and conflict strata and the umbilic phenomenon, will be discussed.

2. Cybernetics. The first and second cybernetic theories (Maruyama, 1974) characterize feedback and feedforward sequence phenomena in behavioral activities. Dimensions of cognitive structure will be analyzed for identifying deviation amplifying and counteracting mutual causal processes. The participants will also discuss the role of closed-loop causality in behavior sequences.

3. Information Theory. The informational content of sequences of figural and verbal behavior can be defined as original and steady state Markov processes (Shannon, 1964). The participants will discuss the useful and noise dimensions of sequences and their relationships to cognitions, mental development, personality and problem-solving.

4. Dynamic and Polychotomic Network Analysis. Sequences of kinds of behaviors can be simulated as networks of node and transmittance branches of signals; and their structure may be measured for saturation, criticality, spaces of ignorance and optimum boundaries. The discussants will offer strategies for avoiding variable assignment traps in network model-building.

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CONCURRENT SESSION B

Session B-5 General Research

Presiding: Stephen F. Godomsky, Jr.
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The Influence of Concrete and Formal Operational Development on the Opinions Secondary School Students Have on the Quality of the Environment

Gabriel Ziccarelli and Gene W. Moser
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The Science Curriculum Improvement Study and Student Attitudes

Jane Bowyer
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and

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and

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A Comparison of Perceptions of Some Basic Science Education Attitudes

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THE INFLUENCE OF CONCRETE AND FORMAL OPERATIONAL DEVELOPMENT ON ON THE OPINIONS SECONDARY SCHOOL STUDENTS HAVE ON THE QUALITY OF THE ENVIRONMENT

Gabriel Ziccarelli
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In a democracy the opinions people have about a social issue often determine future outcomes. The quality of the physical environment in America has been a major issue for the past decade and science education has a principal role in enabling people to define the problems and determine ways in which the environment can be improved. This investigation explored the influence mental maturity of Ss may have on their opinion of the quality of the environment.

A sample of secondary school students (N = 140), living in the suburbs of a major industrial region, was selected (mean age of 15.2 years) and tested with a battery of Piagetian tasks. Forty-nine percent of the Ss were diagnosed as being in the concrete stage of mental development. The Ss then wrote a 15-minute statement of "What do you think about the quality of the environment?" A lexicon of key words from prose statements was developed with the taxonomic classification technique. Stepwise discriminant analysis was then applied for identifying the terms which characterized opinions held by Ss of concrete and formal performance levels of maturity.

A canonical variate of 15 key words significantly discriminated (F-ratio of 10.84; 13 and 110 d.f.) concrete and formal groups, and 86.6 percent of the Ss were correctly classified with Mahalanobis' Statistic (Rao, 1973). The key words, in order of their contribution to discrimination were: environment, factories, problems, recycle, earth (world), towns and cities, botanical plants, rivers and streams, pollution, buildings, ecology, government and laws, smokestacks, ground cover, and dirt. The chronological age groups (14-17 years) of Ss were discriminated (F-ratio of 3.51) by 12 key words but only two of them, ground cover and recycle, were also found in the original canonical variate. As only 59.2 percent of the Ss were correctly classified for their chronological age, it was concluded key words of verbal opinions were more a function of mental development.

Three Piagetian operations (Moser, 1975; Battro, 1973) were found to characterize stages of development and when loaded with eight environment terms, 83.3 percent of the Ss were correctly classified for membership. The operations (op.) and key words, in their order of discriminability were: environment, correspondence (op.), problems, recycle, factories, earth or world, transitivety (op.) class inclusion (op.), industrial plants, government and laws, and shady areas. As only one-fourth of the key words did not enter into the canonical variate of the original analysis it was demonstrated mental operations interact with terms used in expressing opinions of the physical environment.

The discovery, mental development of Ss influences the words they use in expressing opinions of the quality of their environment, has several major implications for how strategies should be developed in educating people on the improvement of the environment. An obvious implication is that, since six of every seven Ss can be identified for their general stage of development by the words they use in expressing an opinion, environmental education curricula should be developed using a Piagetian approach. Since the canonical variate for predicting mental development was found to have a greater discriminatory power than that for predicting ages of Ss, the traditional pedogogic practices of age-grade emphasis should be questioned for its efficacy in influencing improvement in the quality of the environment.

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THE SCIENCE CURRICULUM IMPROVEMENT STUDY AND STUDENT ATTITUDES

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Objectives and Rationale

Considerable funds and effort have gone toward the research and development of science curricula in recent years. The objectives of these various curricular efforts are diverse, yet one goal of nearly unanimous agreement is to develop within students more favorable attitudes toward aspects of science. Although 31 of the major elementary and secondary curricula projects list attitudinal change as an important objective, there have been few evaluation studies to determine curriculum effectiveness in this area.

This study investigated the cumulative effects of the Science Curriculum Improvement Study (SCIS), a six-year program that has as one of its stated objectives the development of positive attitudes toward science. It was hypothesized that (1) students who had been exposed to the complete SCIS program would evidence more positive attitudes than those not exposed to the curriculum and (2) gender differences would not affect student attitudes for those exposed to the complete SCIS program.

Methodology and Design

The validity of most attitude assessment devices has been extensively questioned because of their self-report nature. An alternative instrument, a projective test, was used in this study. The subjects were required to structure their own responses to open-ended test stimuli.

Data was collected in individual interviews with student responses recorded by the experimenter for later scoring. Each interview lasted approximately 12 minutes.

A total of 110 middle-class, sixth grade students from a rural area in Michigan participated in this study. The experimental SCIS group consisted of 28 females and 27 males randomly selected from two elementary schools which provided six years of SCIS for the entire school population. The non-SCIS control group consisted of 28 females and

27 males randomly selected from schools which were identified as educationally equivalent to the experimentals in terms of socioeconomic status, I.Q., and teacher qualifications. The control students did not experience any SCIS curriculum during their six years of elementary schooling.

Instruments and Data

The Projective Test of Attitudes (PTOA) was used in this study to assess student attitudes. The instrument consists of (1) a Word Association Test, (2) a Thematic Apperception Test, and (3) a Sentence Completion Test. Each part uses a slightly different projective technique to assess attitudes toward three concepts: science, experimentation, and the scientist. Validity was established among the three parts of the PTOA using Pearson's Correlation Coefficient (Science: $r = .89$; Experimentation: $r = .91$; Scientist: $r = .90$).

Three judges scored the student responses. Scores ranged between one and seven for each of the three science concepts with seven representing the most positive attitude. Interrater reliability was determined using Kendall's Coefficient (Science: $w = .89$; Experimentation: $w = .93$; Scientist: $w = .90$).

Results and Conclusions

The statistical data indicate that six years of the SCIS program had a significant and positive effect upon students' attitudes toward the concept of science. No significant attitudinal effects toward experimentation or the scientist were detected.

Statistically significant gender differences in attitudes toward science and the scientist were detected in both the SCIS and non-SCIS groups. Overall, girls evidenced less positive attitudes than boys. An exception occurs with the control boys and girls who appear to have the same attitudes toward experimentation.

A content analysis of student responses reveals interesting descriptive differences in attitudes due to gender and SCIS influence. Implications of the results need to be addressed.

A COMPARISON OF PERCEPTIONS OF SOME BASIC SCIENCE EDUCATION ATTITUDES

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During the spring of 1978, an investigation was conducted to determine the status of the elementary science program in a suburban school district. Four instruments were developed and administered: (1) a 13-item survey of the parents' perceptions of their children's attitude toward science and their particular school science program, (2) a 23-item questionnaire for the teachers, (3) a parallel 22-item questionnaire for the principals, and (4) a 4-task interview administered by undergraduate science education students to the children in grades three and five.

The following are some general findings revealed by the 910 parents who responded.

1. 68.5 percent perceived their children as having a high interest in science.
2. 58 percent viewed their children's school science program positively while 35 percent felt unable to judge.
3. 65 percent would like their children to have more science instruction at school while 28 percent were undecided and 8 percent disagreed.
4. 83 percent responded positively to the statement, "I think science is as important for my child as reading, writing, and arithmetic."

The most frequent suggestion for ways of improving the elementary science program centered on including more activities rather than just reading about science.

The data from 56 K-5 teachers indicated high agreement (86.5 percent) that (a) elementary science should enhance children's thinking skills, (b) children learn science best by direct experience, (c) science skills have long lasting value, (d) the present science program helps develop thinking skills, and (e) both theirs and the children's attitude toward science is positive. However, the teachers indicated higher degrees of neutrality than did the parents. For example, in response to the statement, "Science is as important as reading, writing, and arithmetic," 41 percent of the teachers agreed but 20 percent were neutral (compared to only 5 percent parent neutrality). The highest teacher neutrality (29 percent) was shown toward the statement, "Children's interest in science is higher than my interest." The teachers' suggestions for improving the science program dealt more with acquiring additional instructional materials and less with changing instructional procedures.

The six principals indicated strong correlations with the teachers' views. However, the parents and the principals disagreed on the amount of time for teaching science: 33 percent of the principals thought more time was needed whereas 65 percent of the parents wanted more time than was being given. The principals showed the least agreement (33 percent) on the importance of science compared to the three R's.

Twenty-seven undergraduate science education students interviewed 609 children in grades three and five. The Tasks dealt with the skills of observing, inferring, and identifying variables. There was no significant difference between the abilities of the children. But there was a high correlation between the likes and dislikes of the two groups. Both placed the highest preference on "experimenting" or "learning science when we get to do things." The major dislikes related to more passive activities such as reading, writing reports, listening to the teacher, or "not doing anything."

The recommendations elicited the consideration of additional questions as the present perceptions were analyzed. For example:

1. Which of the data and suggestions from the four instruments are worth implementing? How? When? To what extent?

2. What responsibilities do teachers and administrators have toward meeting the preferences of parents and students?

3. How might the differences between perceptions and practices be better resolved?

GENERAL SESSION II

Presiding:
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Topic: The Reception Learning Paradigm

Speaker:
Dr. Joseph D. Novak
Professor of Science Education
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Topic: The Hierarchical Learning Paradigm

Speaker:
Dr. Howard Jones
Professor of Science Education
University of Houston
Houston TX 77002

Topic: The Developmental Learning Paradigm

Speaker:
Dr. Anton E. Lawson
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CONCURRENT SESSION C

Session C-1	Instruction

Presiding:
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Predicting Success in a Non-Calculus Junior College Physics Course

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and

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Genetics Instruction: Audio-Tutorial Laboratory Approach Compared to a Traditional Method

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and

Leverne J. Thelen
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The Role of the Laboratory in Introductory College Biology Courses

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and

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Evaluator:
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PREDICTING SUCCESS IN A NON-CALCULUS JUNIOR COLLEGE PHYSICS COURSE

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and

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The purpose of this study was twofold. First to identify those background factors that relate to student achievement in an introductory non-calculus based physics course in a junior college situation. Most previous research had related to students at four-year institutions. Second, the study sought to identify areas of mathematical skill that would be useful in predicting success in the physics course. The literature revealed that high school achievement in mathematics was a valuable predictor for college level physical science and mathematics. Certain mathematical skills needed to be examined as predictors of success.

Students who completed the introductory physics course from 1975 through 1977 at a junior college were selected as the sample ($n = 117$). Using the course grade as the dependent variable, 15 hypotheses tested the following independent variables as predictors of success: high school grade point average, high school science background, high school mathematics background, SAT scores, age, sex, college grade point average, major, college science background, college mathematics background, and mathematics instrument total and part scores.

The 29-item, locally developed Mathematical Operations Review (MOR) was administered on the first day of class each quarter. This instrument contained sections relating to arithmetic operations, linear and quadratic equations, trigonometry and logarithms, and word problems. The data were analyzed by performing a step-wise regression analysis. The independent variables were examined for significance as they entered the regression equation. The probability level of the F test was set at $p \leq .05$ for inclusion.

College grade point average was found to be the best predictor, accounting for 42.5 percent of the variance. Other variables significant at $p \leq .05$ level were: word problems score, trigonometry and logarithms score, college science background, and high school mathematics background. The regression equation computed was significant beyond the .01 level. The multiple R was 0.763 with a standard error estimate of 0.751. When information on college grade point average was deleted, the factors of SAT-Quantitative score and high school grade point average were also significant. None of the remaining variables were able to enter the equation at the .05 significance level.

Several of the background factors (grade point averages, high school mathematics, and college science background) found to be significant predictors of success in non-calculus based physics at four-year institutions were still useful in a junior college setting. Since the Mathematical Operations Review (MOR) total scores showed a high correlation to the course grade achieved, and the sections on word problems and solving trigonometry and logarithms made significant contributions, there appears to be strong support for using at least some mathematical skills as predictors of success. Future studies should continue to explore the usefulness of such skills as predictors as well as seeking replication in differing settings.

GENETICS INSTRUCTION: AUDIO-TUTORIAL LABORATORY APPROACH COMPARED TO A TRADITIONAL METHOD

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The audio-tutorial approach to instruction has been reported to be effective in a number of science courses described in the literature. However, experimental research evaluating this method in direct comparison to conventional or other techniques has been limited. In the cases where the evaluation of AT format has been reported, it has involved the entire course with no attempt made to identify subtopics best taught by this method. It appeared that in a course dealing with many different areas such as general biology, the AT approach might be more appropriate for some of the topics than for others. This study was undertaken to compare the effects of audio-tutorial laboratory instruction with that of traditional teacher-directed lab instruction in a three-week genetics unit in a college-level general biology course for non-majors.

Students in the class were randomly assigned to two treatment groups. Within each group they were then rank-ordered according to pre-test scores. Randomization was again used to match 42 pairs of students with identical pre-test scores; one member of each pair receiving AT laboratory instruction through the medium of tapes, while the other member participated in a conventional laboratory session. Both treatment groups attended the same lectures and used the same text, laboratory procedures, study guides, etc.

Pre- and post-tests on the genetics unit were administered, and the results analyzed using a 2 x 3 factorial design where one factor was treatment (instructional method in lab), another was entering competency (high, low, and medium blocking on the basis of the pre-test), with the error term subjects within blocks. The SPSS program MANOVA from the University of Massachusetts Computer Center Library was used for this analysis. Results indicated that there was a significant difference between scores obtained with the two instructional methods. The AT format was thus found to be significantly superior to the control method when the entire group was evaluated.

Further analysis by means of a t-test indicated that the low group made a statistically significant improvement under the AT treatment compared to the controls, and that the male students in the AT group also received significantly higher scores than the males in the control group. For other subgroups the differences were not statistically significant, but did reveal a strong trend in the direction of improved performance for the AT group. An attitude questionnaire was administered, and responses concerning the AT method of instruction were positive.

It was concluded from this study that the AT approach is a more effective way to teach the laboratory portion of a unit on genetics than the way in which it is traditionally taught. This is true both for the general population of students and for some of the sub-groups of that total population. At the same time, the sub-groups for which there was no significant improvement did show some trend toward improvement. Therefore, it appears that in a general biology sequence, changing the conventional method of teaching the laboratory portion of a unit in genetics to an audio-tutorial approach would be an effective step toward improving student learning in this area.

THE ROLE OF THE LABORATORY IN INTRODUCTORY COLLEGE BIOLOGY COURSES

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The study was undertaken to identify the objectives of laboratory work, to develop instruments to measure the level of acceptance of these objectives, and to determine the acceptance of the various objectives by faculty, laboratory teachers, and students enrolled in two introductory biology courses at North Carolina State University.

The literature on the functions of laboratory work in science courses was carefully reviewed. On the basis of the 120 functions identified in the literature, two instruments were developed to measure perceptions about the role of the laboratory. Both instruments were sent to a jury of science educators and college biology teachers for their reactions. In addition, preliminary editions of the instruments were administered to students, laboratory teachers, and faculty members at NCSU. Based on the reactions of the jury and the results of the pilot study, the instruments were revised.

One of the instruments, the Ranking Form, was administered to laboratory teachers and faculty at the beginning of the Fall semester of 1977. On this instrument the respondents were requested to rank in importance five major functions of the laboratory. These five functions represented the subscales on the other instrument, the Laboratory Function Form. This instrument contained 35 items to which the respondents could react on a Likert scale. It was administered to students, laboratory teachers, and faculty at the beginning of the semester and again at the end of the Fall semester of 1977.

Kendall's Coefficient of Concordance was used to determine the level of agreement of the respondents on the Ranking Form. Correlations were determined for the relationships between each item and each of the subscales on the Laboratory Function Form. Relationships between responses and selected variables, such as sex, academic major of the students, and experience of the laboratory teacher, were determined using t-tests and F ratios.

It was found that faculty, laboratory teaching assistants, and students enrolled in introductory college biology courses accepted the five major functions of the laboratory identified in the literature: Manipulative Skills; Processes of Science; Knowledge of Subject Matter; Nature of Science; and Attitudes, Interests and Values. The laboratory teachers, students, and faculty in the course for nonscience majors rated these five major functions differently in importance. No important relationships were found between responses and the sex of the respondents or the experience of the laboratory teacher. Students in the course for science majors, regardless of whether or not they were majoring in science, considered Manipulative Skills more important than did students in the course for nonscience majors. Students, laboratory teachers, and faculty members in both courses expected to have facts and classification systems presented in the lecture and not in the laboratory.

Based on the results of the study, it was concluded that the Ranking Form and the Laboratory Function Form both can be used to assess the perceptions of students, laboratory teachers, and faculty members about the functions of laboratory work in introductory courses in college biology.

CONCURRENT SESSION C

Session C-2 General Research

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The Effectiveness of Science Supervisors and Their Membership Within a Faculty

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and

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Future Supply and Demand for Physical Science Teachers in Kansas

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Five Years of Achievement in ISCS Level I

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James V. DeRose
Marple Newtown School District
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Evaluator:
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THE EFFECTIVENESS OF SCIENCE SUPERVISORS AND THEIR MEMBERSHIP WITHIN A FACULTY

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Methodology and Design

Two aspects of the science supervisor/science teacher interaction are examined in this study. First, what contrasts exist in the ways science supervisors and the teachers with whom they work perceive the supervisor's professional behaviors? Second, what is the nature of the relationship between the effectiveness of science supervision and the supervisor's faculty group membership?

The first issue was examined through a comparison of mean responses on the Science Supervision Rating Scale (SSRS) and the Person-Group Relationship Scale—Faculty (PGRS-F); the second through an examination of the correlations between the two measures. It appears that these correlations explain further important constructs of supervisory behavior and suggest how to modify it.

Instrumentation and Data

A mailed survey of three sections served as the chief data source. The first segment provided pertinent demographic information. The SSRS, developed and refined in earlier studies on science supervision (Ritz and Felsen, 1976; Felsen and Ritz, 1978), constituted the second part; it assesses a supervisor's job effectiveness with respect to 26 supervisory activities. The third part of the survey, the PGRS-F, operationalizes Jackson's concept of group membership based on his R-Space framework. Eighteen questions explore aspects of a supervisor's behavior in relation to their faculty peer group. The PGRS-F was developed and validated in studies by Felsen and others (Felsen, 1973; Felsen and Blumberg, 1973a, 1973b, 1973c).

The subjects of the study were a sample of New York State science supervisory personnel (n = 143), and a proportionate random sample of the teachers (n = 250) with whom these supervisors regularly work. The survey was mailed first to the science supervisors, who were asked to rate themselves using the two scales, as well as to provide names of the teachers with whom they work. A second mailing of a slightly modified version of the survey asked teachers to rate their science supervisors on the same two scales.

Results and Conclusions

In order to reduce the data from the 26 items of the SRSS and the 18 of the PGRS-F, and to increase their power for data analysis, a principal components factor analysis with varimax rotation was performed separately on the supervisor and teacher responses as well as on the combined responses. The factors resulting from the separate group analyses are essentially the same as for the combined group factor analysis.

Four factors emerged from the analysis of the supervisory effectiveness questions, and these have been named "instructional intervening," "interpersonal/supporting," "management/planning," and "socializing." Three factors emerged from the analysis of the group membership questions, two of which very closely resemble the two characteristics originally identified by Jackson: "group membership—acceptance" and "group membership—attraction." The third factor was judged not reliable enough for exploration of group membership and was dropped from further analysis.

A one-way analysis of variance was computed on perceptions of the two groups toward supervisory performance as represented by the four factors on effectiveness and the two on group membership. The alpha level was set at $p \leq .05$. Noticeable differences between supervisors and teachers in their perceptions of supervisory effectiveness were found. The supervisors believed themselves to be more involved in instructional intervening activities (such as inservice workshops or co-teaching) than did the teachers. The teachers viewed the supervisors to be less effective at interpersonal and supporting activities than the supervisors saw themselves to be. The supervisors believed themselves to be much less involved in socializing activities than did the teachers. Finally, supervisors believed themselves to be much more accepted into their faculty group in terms of how truthful, argumentative, or friendly they could be; teachers gave the supervisors significantly lower ratings in these categories.

The second issue of whether or not job effectiveness and peer group membership explain constructs of supervisory behavior was examined through canonical correlation analysis (Cooley and Lohnes, 1962). This analysis was performed on the two sets of factor scores across the total group of teachers and supervisors. Two canonical correlations were found to be statistically significant at the $p \leq .05$ level. The first ($R = 0.62$) indicated that the optimal linear combination of ratings of group membership status on the PGRS-F accounted for 39 percent of the variance in supervision effectiveness (as measured by the SSRS). The second canonical correlation, orthogonal to the first ($R = .17$) accounted for 3 percent of the variance shared by the two measures. Examination of the correlations between variables and the canonical variate pairs suggests that the first factor represents general interpersonal/communication behaviors, whereas the second seems to describe personal affect for the supervisor.

These factors suggest that the effect of group membership on supervisor effectiveness is an important one. The relationship can apparently best be explained by two factors; one is interpersonal/

communication skills and the second, which accounts for much less variance than the first, is personal affect. It appears from this early exploration that the science supervisor's effectiveness can be increased by learning new interpersonal skills. The data also tend to support the commonly held view that teachers and their supervisors hold very different perceptions of how effective the supervisor really is.

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FUTURE SUPPLY AND DEMAND FOR PHYSICAL SCIENCE TEACHERS IN KANSAS

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The fall of 1976 was generally recognized as the peak enrollment year for students in grades 9-12. A steady decline in the number of secondary school students is predicted through the year 1990. This decline would result in an estimated 25 percent decline in number of secondary school students. These declining figures suggest that more exacting demographic data needs to be analyzed to provide prospective teachers and administrators with information useful in meeting the challenge of declining enrollments.

The purpose of this paper then is to present longitudinal baseline data for all the high school physical science teachers in Kansas during the 1975-76 and 1976-77 school years. The information will be used to project the future supply and demand for physical science teachers in Kansas according to the size of the school district.

Methodology and Design

Information concerning the previous year employment, and present teaching assignments and class enrollment figures for all the high school physical science teachers were obtained for both the 1975-76 and 1976-77 school years. The age of each teacher was also obtained to compute age-sex composition pyramids for specific subject area teachers in each of five school district categories based on total number of students enrolled. The information for the two-year period will be used to predict the supply and demand picture for 1985.

Results

In 1975-76, 85.1 percent of the physical science teachers in Kansas reported that they had worked for the same school district at least two years in a row. Overall, only 6.5 percent of the teachers have been students the previous year. The smaller the school district the higher the teacher turnover rate. As expected the smaller the school district, the more separate mathematics or science class preparations had to be made. Overall, 41.6 percent of the teachers made three or more separate science or mathematics class preparations each day.

These physical science teachers also instructed 8,672 chemistry students and 3,636 physics students with the ratio being 2.4 chemistry enrollees for each physics student.

The development of an age-structure pyramid provided a graphic picture of the percentage of physical science teachers in each of the following age span or cohort categories:

50 and over	9.9%
45 - 49	8.1%
40 - 44	11.4%
35 - 39	19.5%
30 - 34	22.6%
25 - 29	25.7%
20 - 24	2.9%

Knowledge of the varying turnover rates in each of the cohort categories coupled with stated assumptions regarding retirement, replacement, and staff expansion allows a projection of the age-frequency distribution to the year 1985. The percentage composition of the 20-29 year old cohorts will represent the needed supply of physical science teachers.

In conclusion, this paper represents a demographic analysis of computer data accumulated by the Kansas State Department of Education and provides a possible model for other states interested in predicting supply and demand for teachers in various teaching areas.

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FIVE YEARS OF ACHIEVEMENT IN ISCS LEVEL I

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Rationale

An evaluation of achievement associated with a laboratory-oriented self-pace science program—ISCS Level I—is fundamental to the present research. While numerous comparative, reading attitudinal, and achievement studies have involved this program, few have been more than one year in duration. In studies focusing upon achievement, grades or final test scores commonly are correlated with factors such as aptitude or attitude. Such indices of achievement are limiting and appear to be at odds with the basic tenets of the ISCS philosophy of instruction as they measure outcomes almost exclusively in terms of a group rather than the individual.

Several aspects of the current project serve to distinguish it from prior ISCS studies. First, a five-year period is involved. Second, student achievement is measured in terms of quantity and self-knowledge as well as quality. Third, the data source included all students enrolled in seventh grade science in a suburban school district during the period. Fourth, and perhaps most important, student achievement resulting from a school district committed to ISCS is detailed.

Design and Data Collection

Perhaps "Statistical Case Study" best categorizes the research. Certainly it is both descriptive and longitudinal. Conversely, it is neither experimental nor theoretical. Central to the study is the Marple Newtown School District in suburban Philadelphia. A long-standing commitment to individualized instruction coupled with a science coordinator active in the development of ISCS made district-wide adoption a natural. More important to the study, a commitment to the program's rationale and instructional format helped to insure implementation rather than wholesale adaptation. Some compromises were made—e.g., degree of self-pacing—but programmatic integrity was guarded through inservice workshops and close supervision.

Data were gathered from district files on a series of variables. Six of these—pre and post test scores, chapters completed, excursions completed, quality index, and "know you know" index—were measures of various aspects of achievement. Otis IQ, reading ability, and sex were also quantified. During the five years studied—1970-71 to 1974-75—more than 2800 students were enrolled in Level I.

Data Analysis and Results

Manipulations of data were all descriptive. Basic information including means, standard deviations, and ranges were generated by year as well as for the top and bottom achievement groups. Thus trends could be examined both longitudinally and between achievement groups. Pearson product moment correlations were calculated between IQ, reading ability and the various facets of achievement.

Throughout the five years the population remained quite stable with regard to IQ, reading ability, and sex. Generally, results associated with mean gain scores, and the quality of work exhibited minimal fluctuation. On the other hand, substantial increases were exhibited in the quantity and self-knowledge indices.

Not surprisingly, IQ and reading were highly correlated with the various measure of achievement and with each other. Excepting the first year, males made up a slightly larger percentage of the top and bottom achievement group; yet, females performed slightly better overall.

CONCURRENT SESSION C

Session C-3 Paper Set: Follow-up Studies in Teacher Education: Models for Teacher Evaluation

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Rationale for the Paper Set: Follow-up Studies In Teacher Education: Models for Teacher Evaluation

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Follow-up Studies at Tennessee Technological University: A Model for Teacher Evaluation

Jerry B. Ayers
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How Follow-up Studies Can Help Solve Problems of Beginning Science Teachers

Robert W. Howe
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Follow-up Studies of UPSTEP Graduates at the University of Iowa

John E. Penick
The University of Iowa
Iowa City IA 52242

Discussant: J. Dudley Herron
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Evaluator: Vincent Lunetta
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RATIONALE FOR THE PAPER SET: FOLLOW-UP STUDIES IN TEACHER EDUCATION: MODELS FOR TEACHER EVALUATION

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Follow-up studies in teacher education seem to fall into two general categories: teacher effectiveness and program evaluation. In the first, a model of good teaching is set forth and the extent to which program graduates fit this model is then tested through some combination of survey, observations, and personality inventories. In the program evaluation category, the elements of an existing teacher education program are described and graduates are asked to rate the quality of these elements.

Few institutions have reported extensive follow-up studies. With the press for accountability at all levels, this situation is changing. For example, the state of Ohio has mandated in its new state guidelines for teacher education (to be implemented in 1980) that colleges and universities preparing teachers will conduct follow-up studies of their graduates.

The purpose of any evaluation system is to collect, analyze and disseminate information that is useful for decision-making purposes. The papers presented in this set will provide some potential models for use by science educators as they attempt to evaluate programs at their own institutions to improve the quality of their graduates, to meet state mandates, or to make informed program decisions.

FOLLOW-UP STUDIES AT TENNESSEE TECHNOLOGICAL UNIVERSITY: A MODEL FOR TEACHER EVALUATION

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In 1973 Tennessee Technological University developed and implemented a longitudinal model for gathering systematic data from the graduates of its teacher education programs. The model was based largely on the work of J. T. Sandefur (An Illustrated Model for the Evaluation of Teacher Education Graduates, Washington: AACTE, 1970). The model has served as a base for meeting the evaluation standards of such organizations as the National Council for the Accreditation of Teacher Education and in gathering data and sufficient information for curriculum development and reform in the teacher education programs of the University. The model has application at other institutions desiring to implement programs for improvement of their general teacher education programs and specifically programs in science education.

The application of the model at Tennessee Tech entered its sixth year in 1978-79 with the specific objectives of evaluating the graduates in order to provide information for program improvement at the University. During the period, six distinct groups of subjects have participated in the study, i.e., graduates from the bachelor's and master's level program for the period 1973 through 1978. Detailed information has been collected on each subject from four distinctly different sources: (1) self-evaluative data; (2) principals and supervisory evaluations; (3) satisfaction of students of the graduates; and (4) data from independent trained observers.

The major findings of the study have indicated that each group of first year graduates has changed little over the five-year period for which detailed analyses have been completed. Also few changes have been noted in the subjects who have been in the study for as much as five years. The graduates have exhibited many of the characteristics of good teachers; however, when compared with national samples, they are functioning near the mean. Comparison studies of graduates from specific areas such as science education have been conducted. Even though there have been few apparent changes in the graduates during the period of the study, much valuable information has been gained that provides for ongoing improvement of the teacher education programs of the University. Use of the model in science education and how the findings of the present ongoing study address the important consideration of program modification is highlighted in the paper.

HOW FOLLOW-UP STUDIES CAN HELP SOLVE PROBLEMS OF BEGINNING SCIENCE TEACHERS

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This presentation will review problems of beginning science teachers and the results of follow-up studies related to science teachers. Included in the review will be results from 20 to 30 studies that are pertinent to the problem.

One of the foci of the review will be the cluster of follow-up studies of science and mathematics teachers completed at The Ohio State University. One of these studies involved not only beginning teachers of science but also those with three to five years of teaching experience. Data were obtained from the teachers, their pupils and their administrators relating to the way the in-service teachers taught science, problems they had encountered as teachers, and leadership roles they had assumed within their school faculties.

Recommendations for teacher education, in-service education, and future research will be made.

FOLLOW-UP STUDIES OF UPSTEP GRADUATES AT THE UNIVERSITY OF IOWA

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The Science Education faculty of the University of Iowa is conducting a follow-up study of UPSTEP graduates. The bulk of the study is complete although additional information will be analyzed by January 1, 1979.

The UPSTEP evaluation effort involves three distinct phases: methods courses and other experiences for students to develop a rationale for teaching, student teaching, and post-graduate experiences. In each of these three phases we have collected audio-tapes of classroom performance, data on several pencil and paper instruments such as the Multi-dimensional Assessment of Philosophy of Education (MAPE), and personal anecdotal data. Some of these data are compared against baseline data for the UPSTEP program prior to 1974.

Evidence at this point indicates that changes in UPSTEP students are occurring and that they are occurring in the direction that the UPSTEP developers desire.

CONCURRENT SESSION C

Session C-4 Learning

Presiding:

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The Influence of the Reflective/Impulsive Dimension on Problem-Solving Skills in Elementary School Science

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Differential Response to Prompting and Confirmation in the Acquisition of an Inductively Presented Biologic Concept

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and

S. Dennis Baker
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Pre-Concepts and Pro-Active Inhibition in Learning Science

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THE INFLUENCE OF THE REFLECTIVE/IMPULSIVE DIMENSION ON PROBLEM-SOLVING SKILLS IN ELEMENTARY SCHOOL SCIENCE

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The main purpose of this investigation was to compare performances of grade six students, classified as reflective and impulsive, on response uncertainty problem-solving tasks demanding adoption of (a) a guided-discovery approach and (b) an open-ended approach for completion.

The students were classified as being reflective or impulsive in disposition, or of neither a marked reflective or impulsive disposition, as defined by Kagan, et al. (1964). Guided-discovery tasks required students to select observations and hypotheses pertaining to problem situations depicted on a film-loop, and to subsequently evaluate the selections made in terms of their effect upon the depicted problem situations. Open-ended tasks required students to generate multiple observations and hypotheses pertaining to the same depicted problem situations, and to evaluate the generations made in terms of their effect upon those problem situations.

Reviews of Buros (1965, 1972) indicated that published guided-discovery and open-ended tasks appropriate to the requirements of the present investigation at the grade six level, did not exist. Accordingly, all guided-discovery and open-ended tasks were designed by the investigator. Efforts were taken to ensure that reliabilities and validities of the tasks were brought to as high a level as possible.

In addition to guided-discovery and open-ended tasks, three measures were employed in this investigation to assess students' abilities in observing and in hypothesizing. Content areas and modes of content presentation incorporated in these three tasks differed from those incorporated in the guided-discovery and open-ended tasks. These measures were used to provide information concerning the extent to which observation and hypothesizing abilities can be considered task-specific.

Another purpose of the investigation was to compare the types of questions asked by Reflectives and Impulsives during involvement in those problem episodes used as foci for the guided-discovery and open-ended tasks. Questions asked were subsequently assigned to specific category types according to criteria and format prescribed by Suchman (1962).

One hundred and eighty-four students participated in the study. Of these, 68 were subsequently classified as being reflective in disposition and 70 as being impulsive in disposition.

Analysis of data resulting from administration of instruments employed in this investigation indicated the following:

1. Reflectives perform about as well as Impulsives on tasks measuring abilities in selecting and in generating observations.

2. Reflectives perform about as well as Impulsives in selecting and in generating hypotheses on tasks utilizing the particular content area and presentation mode associated with the film-loop.

3. Reflectives' performance is superior to that of Impulsives in selecting and in generating hypotheses on tasks utilizing content areas and presentation modes different to those associated with the film-loop. In the case of ability to generate hypotheses, Reflectives' performance is significantly superior to that of Impulsives.

4. Reflectives perform about as well as Impulsives on all tasks measuring abilities in evaluating selected and generated observations and hypotheses.

5. Reflectives ask similar types of Suchman questions and similar quantities of questions as Impulsives during involvement in problem-solving sequences.

6. Gagne's (AAAS, 1965) claim that observing and hypothesizing abilities manifest high inter-task generality was only partially supported in this investigation. In instances where tasks did not differ greatly in terms of content area, presentation modality and response requirement, moderately high correlations were obtained between task scores. Where these factors did differ greatly, essentially zero correlations were obtained between associated task scores.

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DIFFERENTIAL RESPONSE TO PROMPTING AND CONFIRMATION IN THE ACQUISITION OF AN INDUCTIVELY PRESENTED BIOLOGIC CONCEPT

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Rationale and Objectives

Inductive instructional systems have many advocates in science education, because such systems engender many inquiry and investigative characteristics valued as outcomes of science instruction (Shulman and Tamir, 1973). Yet summaries of research on concept learning (Clark, 1971; Koran and Koran, 1976; Wright, 1977) indicate that inductive instruction increases the probability of errors and may result in increased habit strength for incorrect responses. Indeed, in the latter two studies students receiving inductive instruction scored no better than chance on criterion measures used, and deductively taught students significantly exceeded those taught inductively. Nevertheless, inductive instruction, where visual or verbal stimuli are presented and students are expected to think, act, manipulate and arrive at regularities in objects and events is built into modern science curricula and is becoming an important component of contemporary models of science instruction (Novak, 1976). Since this is the case this study was designed to explore two questions.

Given an inductive instructional sequence in high school biology:

1. To what extent are prompting or confirmation adjuncts effective in optimizing learning?
2. For whom is the prompting and confirmation adjunct most facilitative, high or low ability students?

Methodology and Design

Sixty-one ninth and tenth grade science students were administered a verbal aptitude test, then randomly assigned to one of two slide-tape sequences on monocots and dicots which were inductively presented. One slide-tape sequence of 30 slides, provided students with specific cues preceding a sequence of slides depicting critical characteristics of angiosperms. (Veination type, fibro vascular bundle organization, petal and sepal number.) Feedback was provided on each slide confirming whether or not the plant shown was a monocot. The cues served as prompts directing student attention to the leaf veination, petal number and bundle organization. The second treatment omitted the cues, and provided only the feedback. The students' task in each case was to infer the defining characteristics of a monocot. The following design was used:

Aptitude R O X_1 O

Test R O X_2 O

Instruments

The verbal aptitude test used was selected from the French Kit of Reference Tests for Cognitive Factors (French, Ekstrom and Price, 1963) as an index of general ability. The criterion measure was a previously unobserved 30-slide sequence of angiosperms which students were shown prior to and after the treatments. A KR21 reliability estimate yielded .82.

Results

Multiple regression analysis was used in analyzing both treatment effects and aptitude-treatment interaction. Both treatments were effective in producing significant increases in performance from pretest and posttest ($p \leq .05$). The prompting treatment, using specific cues plus feedback produced significantly better performance than did the confirmation treatment, using feedback alone ($p \leq .05$).

Verbal comprehension ability interacted significantly with the two inductive instructional treatments ($p \leq .05$). Students with high verbal ability performed best in the confirmation treatment while low verbal ability students performed best in the prompting treatment.

Conclusions

Results of this study support the contention that attention directing and controlling adjuncts improve learning from inductive instructional methods. The use of such adjuncts appears to be particularly beneficial for lower ability learners. Low ability students tend to make more errors during instruction resulting in errorful learning and increased habit strength for incorrect responses (Glaser, 1966). Inserting specific cues focused attention on relevant aspects of the stimulus situation, reduced incorrect responses, and facilitated learning of correct responses, particularly for low ability learners. Hence, for these types of students such adjuncts would appear useful.

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PRE-CONCEPTS AND PRO-ACTIVE INHIBITION IN LEARNING SCIENCE

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While developing curriculum material for disadvantaged children in Israel, a working model for concept attainment has been developed. The model has been tested systematically on some key concepts in teaching and has been utilized in the development of curricular material. The latter has been tried out on 16 experimental classes of disadvantaged children within project "Petach"[1] in the Jerusalem area.

The model pertains to the process of observation and interpretation of a phenomenon or of a situation, as encountered by the child within the enquiry method and also in everyday life.

In that model, key role is allotted to two diametrically opposite groups of cues (visual or other) which reach the child: 1) Cues from the phenomenon or situation, selected by the "pre-concept" (which may be syncretic) which the child brings to the case; 2) Cues from "distractors" (pro-active inhibitors), i.e., features of the phenomenon or situation which are incidental to the concept being demonstrated but are sufficiently prominent to be noticed.

We introduce and define operatively the concept of "relative strength, a priori" of these two groups of cues, in terms of their measurable parameters.

Hypothesis I is that, in all cases tested or tried out, the children tested have a distinct pre-concept, which will enable them to handle the situation correctly—operatively or verbally, provided that the "distractors" are not too "strong" and do not interfere with their conclusions. This is a hypothesis of a priori-existence of pre-concepts.

Hypothesis II is that the actual capability of any given child to deduce the concept from the given experimental setup (as measured by suitable operative or verbal tests) depends crucially, in each case, on the "relative strength" between the two types of cues.

In the cases tested, the method consisted of changing systematically the relative strength of the cues, three or more times, and testing the child for concept attainment separately each time. The possibility of learning from one time to another was eliminated by suitable design of the experiment. Thus, for example, in the case of conservation of volume, the ratio of height : width of the containers can be changed systematically in four consecutive experiments, starting from 5:4 and ending up with 5:1; i.e., in the first, water from a 5:4 container is poured to a 4:5 container. In the second, from a 5:3 container to a 3:5 container, etc. If testing results systematically deteriorate along such sequences in spite of the possibility of learning, this should support the model.

The concepts used were:

1. Volume conservation (at 5-6 years).
2. Conservation of "height" of a bead released on a U-shaped wire (6-10 years).
3. Weight gradation (4-6 years).

The results support Hypotheses I and II in the cases tested.

In curricular planning, the model suggested a method of systematically changing the "relative strength" of distractors in concrete learning situations.

This has been used successfully in 16 classes of K-4 on these and additional concepts, such as: symmetry in collisions at an angle, proportionality, energy sources and consumers and inverse relationship.

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[1] Hebrew initials for "development of thinking," project sponsored by the Israel Ministry of Education, for developing everyday thinking tools via simple everyday science.

CONCURRENT SESSION C

Session C-5 Techniques and Procedures of Research

Topic: Using Group Tests to Assess Piagetian Levels of Cognitive Development

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Participants will learn to use group tests designed to assess Piagetian levels of cognitive development from early concrete (2A) through late formal (3B) operational thinking. The tests, which were developed by a British research group, are administered through the use of a series of demonstrations and the collection of data which pupils record. Pupils then use individual response sheets to answer questions which refer to the demonstrations and recorded data. The tests, called Class Tasks, correspond closely to original Piagetian tasks on Volume and Heaviness, the Pendulum, Equilibrium in the Balance, Flexible Rods, Chemical Combinations and the Inclined Plane.

CONCURRENT SESSION D

Session D-1 Paper Set: The Socio-Scientific Reasoning Model
Past, Present, and Future

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Socio-Scientific Reasoning: A Model for Science Curricula

Janey M.Y. Cheu
Louis A. Iozzi
June P. Maul

"The Coastal Zone: Man and Nature": An Application of the Socio-Scientific Reasoning Model

June P. Maul
Louis A. Iozzi
Janey M.Y. Cheu

Socio-Scientific Reasoning: An Evaluation of Curriculum Materials Based on the Socio-Scientific Reasoning Model

Gayle Henkin
Louis A. Iozzi
June P. Maul
Janey M.Y. Cheu

The Environmental Issues Test: An Assessment Instrument for the Socio-Scientific Reasoning Model

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SOCIO-SCIENTIFIC REASONING: A MODEL FOR SCIENCE CURRICULA

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The all persuasive influence of science and technology in our society places an imperative on scientific literacy among its citizenry.

Understanding the world we live in requires knowledge of scientific concepts; living in today's world requires decisions about how science and technology are applied—from questions of pest control to safety regulations on scientific research. Since we live in a world of increasing international and interpersonal dependency, one's decision has far greater social/political/economic impacts and widespread consequences.

A scientifically literate citizenry is in essence a responsible decision-maker and effective problem-solver whose judgments are wise and cognizant of future impacts. Inextricably linked, therefore, to each scientific-technical judgment are value conflicts; e.g., the need for energy vs. the protection of our environment; new genetic strains vs. potential genetic disasters.

In order to develop the conceptual skills necessary for ethical decision-making about value conflicts in science, we have developed a curriculum model based on the cognitive-developmental approach of Jean Piaget for scientific reasoning, Lawrence Kohlberg for social/ethical reasoning, and John Dewey for problem-solving strategies. This socio-scientific reasoning model integrates the hypothetical-deductive mode of scientific problem-solving with the moral/social concerns of ethical decision-making. The model, which has served as the basis for the design of curriculum materials, is based on the assumption: decision-making in a technical society requires simultaneous development in the realm of logical-scientific reasoning and social-moral/ethical reasoning.

The socio-scientific reasoning model, having been designed as a flexible and adaptable strategy for creating curriculum materials, is applicable to any field of science. Interfacing science, technology, and society, this model has generated a number of curricula strategies and resultant activities designed to stimulate the upward progression through the stages of scientific/logical as well as social/moral reasoning. In addition to serving as the basis for the development of a one-year science curricula in coastal ecosystems, it also has served as the basis for mini-courses and simulations in the field of environmental decision-making, bioethics, energy demands, science fiction, and land-use planning.

THE COASTAL ZONE: MAN AND NATURE
AN APPLICATION OF THE SOCIO-SCIENTIFIC REASONING MODEL

June P. Maul
Louis A. Iozzi
Janey M.Y. Cheu

The socio-scientific reasoning model (SSR) can serve as the underlying structure for curricula addressing the ethical issues at the interface of science and society. At its inception, the socio-scientific model guided the development of curriculum materials to be used in conjunction with or incorporated into existing curricula. Currently, it has been applied in the development of a full-year course.

Man has a universal yearning for the coast, its smooth beaches, its picturesque horizon, shimmering sands, sea gulls, sea-worn pebbles, and minute swimming sea animals. This coastal system has also been one of the most productive of the earth's ecosystems. However, it is currently under enormous pressures created by increasing population, industrialization, and the use of technology. Many environmental ethical problems and issues have developed as a result of these pictures. Solutions to these problems necessitate the creation of a scientifically literate citizenry capable of integrating the critical moral/ethical reasoning skills with the factual/knowledge components of the applicable sciences—applying the resulting "cognitive structures" to the management of our coastal zone.

The socio-scientific reasoning model incorporates a logical/physical reasoning component as defined by the Kohlbergian paradigm and a decision-making strategy based on the work of Dewey. Each of these have important educational implications and have guided the development of specific activities including role-playing, simulations, trend analysis, dilemma discussions, scenario writing, hypothesis generation and testing, problem-solving, variable manipulation and model building, which will be presented in this paper.

An evaluation for this curriculum has been designed incorporating tests of social/moral reasoning skills, critical thinking skills, and logical/physical reasoning skills. These instruments will be administered to the students participating in the pilot program (experimental group) and to a group of matching students serving as a control group. After completing the intervention, both the experimental group and the control group will be administered the battery of tests previously administered. Mean scores of the experimental and the control groups will be compared using a matched-group t-test to determine if the experimental group achieved statistically significant improvement when compared with the control group. If the experimental group achieves significant gains in scores ($p \leq .05$), the materials will be considered effective in meeting the goals of the project.

SOCIO-SCIENTIFIC REASONING: AN EVALUATION OF CURRICULUM MATERIALS BASED ON THE SOCIO-SCIENTIFIC REASONING MODEL

Gayle Henkin
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To address the need to develop a scientifically literate citizenry, the socio-scientific reasoning model was created to guide curriculum development. The goals of this developmental approach include increasing:

1. students' skills in dealing with problems containing multiple interacting variables,
2. students' decision-making skills incorporating a wide social perspective,
3. critical thinking skills in the evaluation of consequences and implications of decisions.

Secondary school students (grades 7-12, from both public and private sectors) enrolled in courses in chemistry, earth science, biology, health, social sciences, and physics are currently participating in the field test and evaluation of these curriculum materials. Tests designed to evaluate knowledge, critical thinking, and moral/ethical reasoning have been administered to approximately 1,000 students. The experimental design for the field test is the non-equivalent comparison group design where experimental and control groups are pre-tested and post-tested. Mean scores of the experimental and control groups are compared using a t-test to determine if the experimental group achieved significant improvement in the cognitive and affective domains.

Preliminary analysis of the data has indicated that these curricula materials have the potential to affect development in both the cognitive and affective domains.

THE ENVIRONMENTAL ISSUES TEST: AN ASSESSMENT INSTRUMENT FOR THE SOCIO-SCIENTIFIC REASONING MODEL

Louis A. Iozzi
Janey M.Y. Cheu
June P. Maul

Lawrence Kohlberg has postulated a set of moral/ethical values which he claims are culturally universal and non-relative. Analysis of a wide variety of environmental issues and conflicts demonstrates that the basic values postulated by Kohlberg are also the sources of unresolved environmental value conflicts. Hence, the cognitive developmental paradigm developed by Kohlberg is particularly appropriate for values education dealing with the environment.

The Environmental Issues Test (EIT) is a validated assessment instrument based on the Kohlberg model and designed for environmental education programs at the secondary school level and beyond. The format of the EIT is such that besides being unique for obtaining baseline data on Ss from grade 9 through adulthood, it has proven to be useful in intervention studies. Moreover, the EIT is helpful in determining the extent of affective change in people as a result of using various types of environmental education programs, techniques, methods, media, and simulation games dealing with the environment.

The EIT has been used as one of the instruments assessing the socio-scientific reasoning model. Those issues which are addressed by the EIT are common to many of the sciences in that they involve the concepts "the quality of life" or "individual rights" or "duties and obligations" or "law and punishment." This paper will not only describe the EIT and some of our results, it will also discuss the need for the development of a Scientific Issues Test (SIT) designed in parallel to the EIT model.

CONCURRENT SESSION D

Session D-2 General Research

Presiding:

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A Comparison of Identity and Equivalence Scores of 64 Third Grade Children

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A Study of the Effects of Calculator Use on Computational Proficiency

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A Study on Cognitive Development of Nepalese Children

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Evaluator:

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A COMPARISON OF IDENTITY AND EQUIVALENCE SCORES OF 64 THIRD GRADE CHILDREN

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Rationale

If Piagetian tasks are to be given to children for diagnostic purposes, it becomes important to focus on these tasks. It has been suggested by Elkind that conservation tasks involving the conservation of identity and equivalence will or could produce varying results. Piaget and Inhelder also suggested that conservation of identity occurs before conservation of equivalence.

This study was designed to compare the conservation of identity and equivalence responses of third grade children on several tasks: conservation of solid amount; continuous amount; discontinuous amount; weight; and area. In evaluating childrens' cognitive structures, we obviously want accurate and complete information, but it is also true that Piagetian interviewing techniques are very time consuming and require special skills for complete accuracy. This is especially true for the classroom teacher who may want to evaluate her pupils in order to adjust instructional strategies. It therefore seemed reasonable to ask: How necessary is it to administer both identity and equivalence tasks to individual children for diagnostic purposes?

Method

Sixty-four third-grade children were given conservation of identity and equivalence tasks in each of the five areas mentioned. There were 32 randomly selected girls and 32 randomly selected boys who were given a random assignment to one of two sequences: identity task first, followed by the equivalence task; and equivalence task first, followed by the identity task. This provided an opportunity to evaluate the effect of the variables of sex and sequencing on the final results.

Results and Conclusion

All comparisons of the conservation of identity and equivalence tasks produced correlation coefficients of at least .90, ranging from .90 for conservation of liquid (continuous) amount to .97 for conservation of area. Total scores for the 64 children correlated .94. The maximum number of children passing both tasks was 51 (79.7 percent) for discontinuous amount while the maximum complete agreement, whether passing both or failing both, was for conservation of area at 96.9 percent. The least percentage of agreement was for conservation of liquid amount. When all five tasks are considered (total scores), it was found that 72.8 percent passed both tasks, 19.1 percent failed both tasks, and only 8.1 percent conserved for either identity or equivalence but not the other.

Analysis of variance for the total conservation of identity and equivalence scores indicated that neither sex nor sequence of tasks was significant ($p \leq .05$): $F (1,63) = 0.12$ for sex, and $F (1,63) = 1.45$ for task sequence.

A comparison was also made between scores on continuous amount and those for discontinuous amount, producing a correlation of .72. This figure compares favorably with the correlation of .66 recorded by Goldschmid.

It would appear from the data that there would not be sufficient knowledge gained for instructional purposes from the administration of both identity and equivalence tasks to make this effort worthwhile. The most significant factor to consider is the purpose of securing the information, and if this purpose is simply to gather data which may assist instructional efforts, it does not seem to be necessary or appropriate to evaluate all of the tasks.

A STUDY OF THE EFFECTS OF CALCULATOR USE ON COMPUTATIONAL PROFICIENCY

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Calculator research studies reporting significant findings favoring the calculator's use are more prevalent for studies conducted in the elementary grades, 58 percent of all studies conducted, than for studies conducted at the secondary level, 25 percent of all studies. The purpose of this study was to investigate the possible influence of Piagetian levels of cognitive development, level of content, and level of testing on these reported results.

Lawson's (1978) Classroom Test of Formal Reasoning was utilized to measure Piagetian cognitive level, and a mathematics instrument, developed by the investigator, was used to provide measures for problems combining various content and testing levels. Subjects were blocked by cognitive level of development, randomly assigned to calculator and no calculator groups, and were administered the mathematics instrument. A multivariate analysis was performed upon the scores of the mathematics instrument.

Statistical significance was found only for the main effects of cognitive level of development, $F(4,56) = 5.817$, $p \leq .001$; however, the data did suggest a possible calculator use-cognitive level of development interaction effect. This interaction effect may have been masked by: 1) the extremes of age and grade level of the population sampled, 2) the small sample size, and/or 3) the extremes in cell sizes within the multivariate design.

A continuation of this study designed to alleviate these shortcomings is in progress, and if an identifiable cognitive level of development-calculator use interaction effect can be discovered, the design of all future, and the interpretation of all, calculator research would be greatly enhanced.

Reference

Lawson, A. E. "The Development and Validation of a Classroom Test of Formal Reasoning." Journal of Research in Science Teaching, 15: 11-24, January 1978.

A STUDY ON COGNITIVE DEVELOPMENT OF NEPALESE CHILDREN

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This is a study on the cognitive development of Nepalese children which was conducted recently (July, 1977 to April, 1977) in order to seek answers to the following questions:

a. What is the pattern of cognitive levels of Nepalese children within the age groups 8-12?

b. How do children differ in their cognitive abilities from one region of the country to another, these regions differing greatly in industrialization, one being the capital city of Nepal, and the other a hilly village in mid-northern Nepal?

c. How does the present science curriculum framed, and executed under the New Education system Plan (1971-1976), relate to the developmental levels of the learners?

d. How do the Nepalese children compare in their cognitive abilities to children from a highly industrialized country like U.S.A.?

Answers to these questions were sought by administration of the following tasks to the 8, 10 and 12 year school going children of two different regions of the country—Kathmandu and Pokhara. Katmandu is the capital city of Nepal and Pokhara is a hilly village.

a. Conservation of length, area, volume (displacement), weight and substance (liquid)

b. Classification, using representational items

c. Multiple classification

d. Multiple Seriation

e. Causality: (i) Concept of Life; (ii) Movement of Clouds

f. Concept of Earth and Gravity, utilizing structured interviews.

The pattern of responses to the tasks of the children in the two regions were then compared. The task responses of the children were compared to their present science curricula. Also comparison was made between the task responses of Nepalese children to their U.S. counterparts.

Conclusions

In some instances, the life style of village children, which demanded of them to perform certain functions promoting cognitive abilities not required of the city children was found to accelerate the growth of certain concepts and skills in them.

In general, schools with modern facilities were more effective in promoting cognitive development than schools lacking in modern facilities.

This study, which was prompted by the need of basing curriculum development in Nepal on the cognitive development of learners, has important implications for curriculum developers of Nepal.

Nepalese children are seen to fall behind their U.S. counterparts in certain areas. Retardation is seen as a function of life style rather than of genetic or psychologic factors.

CONCURRENT SESSION D

Session D-3 Inservice Teacher Education

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The Effects of an Academic Year Workshop on Energy Upon the Understanding of Energy Alternatives and Their Economic and Political-Social Ramifications and Selected Energy Related Attitudes of Secondary Science Teacher Participants

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An Analysis of Outcomes in an Energy Education Workshop for Junior and Senior High School Teachers of Science

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Effectiveness of a Metric Leader Training Project

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THE EFFECTS OF AN ACADEMIC YEAR WORKSHOP ON ENERGY UPON THE UNDERSTANDING OF ENERGY ALTERNATIVES AND THEIR ECONOMIC AND POLITICAL-SOCIAL RAMIFICATIONS AND SELECTED ENERGY RELATED ATTITUDES OF SECONDARY SCIENCE TEACHER PARTICIPANTS

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A new energy literacy must be a primary goal of science education. Secondary science teachers should be knowledgeable not only in the science aspects of energy alternatives but also in the economic and political-social ramifications. Curriculum with meaningful instructional activities must be developed and presented. Secondary students upon reaching 18 years of age will be making voter decisions on energy policy and adjusting life styles according to the availability of energy.

The purpose of this study was to determine the level of knowledge of secondary science teachers before and after each academic quarter of workshop presentation on various energy alternatives and their economic and political-social ramifications. The study also investigated the selected energy related attitudes of secondary science teachers before and after a study of nuclear energy, solar energy, and conservation of energy. The third focus of this investigation was to determine whether liaison between secondary science teachers and university faculty and/or university resources had been established by participation in the workshop to facilitate the continuing study of the energy problem.

The first quarter of the academic year workshop on energy alternatives and their economic and political-social ramifications focused on the general crisis situation, natural gas, petroleum energy, wave energy, and geo-thermal energy. The second quarter focused on solid fuels, wind energy, and energy from electricity and batteries. The third quarter focused on nuclear energy, solar energy, and the conservation of energy.

A short Likert-type questionnaire was employed at the beginning and at the end of the third quarter presentation to determine whether attitudes about nuclear energy, solar energy, and conservation of energy had changed. Each quarter a mastery test on the energy topics presented was administered as a pretest and posttest to determine whether there was an increase in the level of knowledge on energy alternatives and the economic and political-social ramifications. An information questionnaire was administered on the first day and on the last day of the academic year workshop to determine whether secondary science teachers had contacted university faculty or used the university library resources.

The results of the six-item Likert-type questionnaire indicated that there was no significant attitude changes toward the employment of nuclear energy, solar energy, and the conservation of energy to meet the energy demand in the United States. However, on the item relating to the use of a number of energy sources rather than the use of nuclear energy or the use of solar energy or a combination, there was a significant change ($p \leq .05$). There was a significant increase in the knowledge of the energy alternatives and the economic and political-social ramifications presented each quarter ($p \leq .01$). The information questionnaire indicated an increase in opportunities to confer with university faculty and an increase in the use of library facilities.

The implications of this research include the success of an academic year workshop in providing the subject-matter background in energy required by secondary science teachers. Another implication is that contact with university faculty and resources can be strengthened by participation in an academic year workshop. The liaison between the secondary science teachers and the university would facilitate continued study of the energy problem. A third implication is that selected attitudes of secondary science teachers on nuclear energy, solar energy, and conservation of energy appear to be unchanged by a workshop presentation on these topics.

Note

Some or all of the materials incorporated in this work were developed with the financial support of the NSF Grant #77-13558.

AN ANALYSIS OF OUTCOMES IN AN ENERGY EDUCATION WORKSHOP FOR JUNIOR AND SENIOR HIGH SCHOOL TEACHERS OF SCIENCE

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Energy education has become a very popular area since the oil embargo of late 1973. Literature has been published by a variety of organizations and individuals; schools have developed and have offered courses; and federal and state governments have allotted money for the education of energy education teachers. Little data are available that describe the effectiveness of these programs and materials or are there data available that describe the current knowledge about energy and attitudes toward energy problems possessed by our science teachers. This study was designed to provide the foregoing types of data.

Specifically, the study was designed to:

1. measure the cognitive growth of science teachers in an energy education workshop in the areas of: knowledge about energy resources, knowledge about the use of energy, and knowledge about energy conservation.
2. measure the stated attitude change of science teachers enrolled in an energy education workshop in the areas of: individual responsibility, collective citizen responsibility, corporate responsibility, governmental/legislative responsibility, and global responsibility.
3. determine the nature of energy education programs in selected junior and senior high schools.

A pretest-posttest control group design with 24 inservice science teachers serving as the experimental group and 30 preservice teachers serving as the control group was used in this project. The inservice teachers were selected from all those teachers who applied to attend a National Science Foundation sponsored energy education project. It is the author's opinion that those teachers selected to participate in this project are not significantly different from the population of science teachers as a whole. Pretest data were collected in the fall of 1977, and posttest data were collected in the spring of 1978.

The Energy Inventory developed by The Biological Sciences Curriculum Study was used to collect data to answer hypotheses one and two. This inventory contains 100 items and has eight subscales that correspond to the areas listed in hypotheses one and two. Data to answer hypothesis three were collected with an instrument developed by this author. The instrument collected information about content, activities, and organization in the junior high or senior high energy education program.

The experimental group demonstrated significant growth ($p \leq .08$) on seven of the eight subscales of the Energy Inventory. Growth was not statistically significant on the individual responsibility subscale.

Information collected about the nature of energy education programs in the secondary school indicates that two-thirds of the respondents taught units that were one to three weeks in length while one-third of the respondents taught longer units. The content and activities used in these units paralleled the content and activities used in the inservice course in which the respondents were participating.

Data collected from this study would seem to indicate that there is a need for both preservice and inservice education of teachers with respect to knowledge about energy and attitudes toward the use of energy. Further, the data would seem to indicate that teachers, if given specific information, ideas, and encouragement can and will develop an energy education program for their junior high or senior high school classrooms.

EFFECTIVENESS OF A METRIC LEADER TRAINING PROJECT

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The Maine Metric Leader Training Project[1] was organized and conducted during academic year 1977-1978 to train volunteer metric trainers who would in turn provide metric instruction to other adults. The program included five three-hour workshops at seven regional sites in Maine ranging from South Portland in the southern area to Van Buren in the northern tip. Media advertising as well as leaflet announcements printed in both English and French were used to locate a cadre of 450 interested people. Approximately 250 persons finished the complete training program and indicated commitment to conduct training programs of their own. Participants in the program represented a wide range of occupational groups; about 75 percent were educators whereas the remainder included various job areas.

This study was undertaken to determine how well the project reached its objectives of informational and attitudinal growth of program participants as well as an assessment of the frequencies of offering training by participants at the conclusion of their training.

Instruments and data sources used in the study included the following:

1. Biographic Data Questionnaire (BDQ)
2. Opinionnaire About Metrics (OM)
3. Metric Competencies Quiz (CQ)
4. Session Evaluations (for sessions (SE) 1,2,5)
5. Training Report Their (TR) Training of Other Adults.

These instruments and forms were designed by an outside measurement consultant in conjunction with the project staff. The BDQ and OM were administered to all those participating in Session 1, OM was also given at Session 5. The competencies quizzes (MCQ) were administered pre and post. This instrument measured the degree to which participants could estimate quantities such as the mass of water in a coffee cup and its temperature. Session evaluations were conducted for every other session. A training report (TR) was requested from each participant one month following the end of the five training sessions. The TR requested participants, effectiveness of sessions, nature of the training sessions led by the participant in his/her community.

The research questions are as follows:

1. Which metric competencies were significantly[2] enhanced by the experiences?

2. Which attitudes towards the metric system significantly changed?

3. What interactions exist among occupational groups and attitudes towards the metric system?

4. What interactions exist among occupational groups and metric competencies?

5. What interactions exist among occupational groups and success of participant conducted metric sessions?

6. What are the characteristics of the most effective metric leaders?

Data analyses included t-tests, analyses of variance and multiple regression analysis using SPSS. Conclusions support the use of the ripple-multiplier organization employed in the project. Elementary and secondary school teachers were the most effective metric leaders identified. Significant positive changes in both attitude toward the metric system and skills in using it were observed for the participants.

FOOTNOTES

1. Supplemented by a grant from the Metric Bureau, U.S. Office of Education: Grant No. G007700833. Conducted by the College of Education, University of Maine at Orono.

2. Comparisons will be considered significantly different at $p \leq .05$.

CONCURRENT SESSION D

Session D-4 Symposium: Data Collection

Presiding:

W. D. Moorehead
1314 Jones Street
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A symposium on Innovative Approaches to Data Collection

Members:

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A SYMPOSIUM ON INNOVATIVE APPROACHES TO DATA COLLECTION

Willard J. Jacobson
Richard J. Andren
Gary C. Bates
Mitchell E. Batoff
Kelvin C. James

This will be a symposium on research methodology with emphasis upon new and innovative approaches to data collection. It can be argued that our research cannot be better than the data that we collect, and sometimes our research has been limited by a paucity of instruments and data collection approaches available. An aim of this symposium is to broaden the range of possible approaches to data collection.

On the panel for this symposium will be four researchers who have used innovative approaches to data collection in their research. Some of these data collection methodologies may have been used to a considerable extent in some of the social sciences but have not had wide usage in science education research. The panel members will describe methods of data collection that they have used, discuss some of the problems that they have encountered in their research, and answer questions from others who may wish to consider using these approaches to data collection in their research.

The approaches to data collection that will be described and discussed are:

Content Analysis of Investigative Reports

The Use of Interactive Computer Approaches to Provide Preservice Interns with Classroom Diagnostic and Assessment Information

The Telephone Interview in Formative Evaluation

Guided Interviews and On-site Observations

Semi-structured Approaches to Oral History.

CONCURRENT SESSION E

Session E-1 Paper Set: Metaphorical Abilities

Presiding:
Delmar Janke
Dept. of Education
Texas A & M University
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Metaphorical Abilities of Children Ages 2-15 as Related to Graphics, Text, and Creativity

Paper 1: Findings and Theory

Paper 2: Significance and Application for Preschool Children

Paper 3: Significance and Application for Primary and Intermediate Children

Paper 4: Significance and Application for Middle School Children

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Evaluator:
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METAPHORICAL ABILITIES OF CHILDREN AGES 2-15 AS RELATED TO GRAPHICS, TEXT, AND CREATIVITY

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Problems

The problems are three: What are children's analogical abilities? How do they vary with age and sex? And, how do they relate one to another? These interrelated problems cannot be separately studied.

Procedures

An instrument of seven activities was developed and presented in individual tape recorded interviews of 20 to 30 minute duration to 140 children. Ten children of each age from 2 through 15 years were interviewed. To randomize the sample, only those children having birthdays during the month of the interview were interviewed. This procedure gave age specificity for data analysis. The tapes were transcribed onto data forms according to prescribed evaluation procedures.

Instrument activities include: a) interpreting verbal analogy problems, b) interpreting figurative analogy problems, c) stating the reasoning leading to the solution to verbal analogy problems, d) stating the reasoning leading to the solution to figurative analogy problems, e) selecting pictures of analogous events for a story concept, f) speaking and writing with analogies, and g) recognizing analogies in context while listening or reading. An interrater reliability check on the survey instrument gave an 85 percent level of agreement for all tasks. Statistical reliability for activities a-d was 0.894 as determined using the Kuder Richardson (formula 20) procedure.

Data analysis techniques employed were: performance averages and ranges by age for the activities, significant score patterns, mean and standard deviation based on three year age spans, correlations, and analysis of variance.

Results

There is no significant relationship between: 1) age and performance on individual analogy activities. Accepted for activities e and f. Rejected for activities a-d, and g; 2) the sex of the child and performance on individual analogy activities. Accepted for activities a-d, and g. Rejected for activities e and f; 3) performance on verbal and figurative activities. Accepted; 4) performance on different analogy activities. Accepted; 5) identification and use of analogies in speech and writing. Accepted for both types of analogies (personal, direct, symbolic, and fantasy) and grammatical classes (simile and metaphor).

Conclusions

Based on these results, the outstanding data in figures and tables, the phenomena reported on activities f and g, and with respect to the limitations inherent in this study, the following conclusions are warranted:

1. Many abilities comprise children's analogical thought. Their analogical abilities include at least those exhibited in the seven activities in this survey.
2. Children develop the abilities of interpreting both verbal and figurative analogy problems and of speaking and writing using analogies gradually.
3. Children develop the abilities inherent in activities c, d, e, and g immediately upon concept awareness.
4. Children as early as four years old exhibit analogical abilities inherent in activities b, e, and f.
5. By the intermediate grades, children exhibit all analogical abilities identified in this study.
6. Children's abilities to write and speak with analogies differ from their abilities to recognize analogies as they listen or read.
7. Children speak and write with analogies freely when analogy use is acceptable and encouraged.
8. During pre-adolescence, children's abilities on activities a and b are greater than on activities c and d. Adolescents perform verbal activities (a and c) with equal ability; for figurative problems, their ability to state the reasoning leading to the solution exceeds their ability to interpret the problems.
9. The expressive activities (e and f) are not age dependent.
10. Sex is related to abilities for the expressive activities (e and f). Girls exhibit greater ability on activity e. Boys exhibit greater abilities speaking with analogies during preschool years; girls exhibit greater abilities during elementary years; and both sexes exhibit equal abilities during adolescence.

Recommendations

How these ability patterns relate to J. Piaget's model of learning, L. S. Vygotsky's stages, and change with W.J.J. Gordon's synectics activities needs investigation.

CONCURRENT SESSION E

Session E-2 Teacher Attitudes

Presiding: Eileen M. Mays
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Science Teachers' Opinions Relative to the Importance and Perceived Achievability of Selected Goals of Science Education

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A Comparison of Students' and Teachers' Viewpoints of Science Instruction and Science-Oriented Careers

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Effect of an Inservice Program on the Attitude of Junior High School Science Teachers and the Relation of this Attitude to Student Achievement

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SCIENCE TEACHERS' OPINIONS RELATIVE TO THE IMPORTANCE AND PERCEIVED ACHIEVABILITY OF SELECTED GOALS OF SCIENCE EDUCATION

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Bloom, Hastings and Madaus (1971) have stated:

> If the role of education is to produce changes in learners, then someone must decide what changes are possible and what are desirable . . . There is no doubt that the task of determining the objectives of instruction must rest largely with the teacher.

The objectives of this study were to determine science teachers' opinions concerning:

1. What goals of science education are most important (highest priority) and least important (lowest priority)?
2. What goals have the greatest chance of being achieved and the least chance of being achieved (highest and lowest expectation)?

A third objective was to determine the degree of congruence that existed between the priorities and expectations of the teachers.

The method utilized was that of a descriptive survey of 50 science teachers randomly selected from the total population of public middle and junior high school science teachers in a midwestern state. Each teacher was asked to select, from a list of 11 goals, the two goals they perceived as: 1) most important; 2) least important; 3) having the greatest chance of being achieved; and 4) having the least chance of being achieved.

An opinionnaire containing 11 goals of science education was constructed. The goals were selected from an initial collection of 571 objectives from 90 different lists published in textbooks, curriculum projects, public school syllabi and journal articles. The initial objectives were grouped into categories and ranked by frequency of citation. Each of the 11 goals finally selected was cited 12 or more times in the original collection. They were randomly ordered on the instrument.

The goals selected as most and least important, and having the greatest and least chance of being achieved were rank ordered within each of these categories by frequency of selection. The relationship between the priorities and expectations of the teachers was determined by calculating a "coefficient of congruency" according to the method developed by Tamir and Jungwirth (1972).

The teachers varied considerably in their opinions about the desirability and feasibility of science teaching objectives. No single objective was selected by a majority of the teachers as being most important or least important. Forty percent assigned highest priority to student understanding of scientific processes, while 28 percent selected "Science and Society" and 24 percent chose "Content" in this category. Forty-eight percent considered the acquisition of psychomotor skills to be the least important goal.

Forty percent of the teachers perceived the understanding of specific scientific concepts, principles, and theories to be the goal most likely to be achieved by their students. Nearly 60 percent selected awareness of the cultural and historical aspects of science as the least attainable goal.

Few of the teachers (10 percent) exhibited a high degree of congruency between their goal priorities and expectations, while a greater proportion (44 percent) showed little or no congruency between their goal selections. It may be concluded, therefore, that the science teachers frequently did not believe the goals they selected as most important to be those which could be readily achieved in their classroom situations.

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Bloom, B. S.; J. T. Hastings; and G. F. Madaus (eds.). Handbook on Formative and Summative Evaluation of Student Learning. New York: McGraw-Hill Company, 1971.

Tamir, Pinchas and Ehud Jungwirth. "Teaching Objectives in Biology: Priorities and Expectations." Science Education, 56:31-9, 1972.

A COMPARISON OF STUDENTS' AND TEACHERS' VIEWPOINTS OF SCIENCE INSTRUCTION AND SCIENCE-ORIENTED CAREERS

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Rationale

There has been a recent and justifiable movement toward career education in the elementary and middle schools. A goal of career education is to expose children to various careers in the hopes that such exposure will help children make wise academic and career decisions. There is some doubt, however, concerning the congruence of intermediate teachers' ideas of careers and their students' ideas of careers. In general, it seems that few of these teachers realize that their students are quite interested in learning about careers. This study was conducted to ascertain the level of congruence between students' and teachers' thoughts on science instruction and science-oriented careers.

Procedure

The study involved 224 elementary school teachers from the midwest United States. Each grade level from kindergarten through sixth grade was represented by 32 teachers. The study also involved the 5,142 students of the 224 teachers participating in the study. There were approximately 736 students represented at each grade level. The 224 teachers were mailed a questionnaire which instructed them to answer the question, "What do you think your students want from school?" They were also asked to be as specific as possible. After the teachers recorded their answers they were then instructed to ask their students the question, "What do you want from school?"

The students in kindergarten, first, and second grade gave their answers orally. The teachers of these students recorded these oral responses. The students in the other grade levels recorded their own answers to the question. Teachers in departmentalized situations obtained answers from only one of their classes. In all cases, every teacher and student could generate as many answers to the questions as they wished.

Analysis

The teachers' responses to the question, "What do you think your students want from school?" were tabulated by grade level, e.g., all the first grade teachers' responses were isolated from the other grade level teachers. The students' responses to the question, "What do you want from school?" were isolated and tabulated in the same manner. The teacher and student responses were also grouped by primary grade level (grades K, 1, 2) and intermediate grade level (grades 3, 4, 5, 6).

The obtained responses were then analyzed by the test for significance of difference between two proportions. In this method of analysis the proportion of teachers generating the same response is statistically compared to the proportion of their students generating the same response.

Results

The following are some of the results concerning science and science-oriented careers that were obtained from the study:

1. None of the primary teachers or primary students mentioned learning or doing science.
2. None of the primary teachers of primary students cited a desire to learn about a science-oriented career or any career.
3. Two of the 128 intermediate grade level teachers (1.6 percent) mentioned learning or doing science. Whereas, 795 or 27 percent of their students wanted to learn or do more science.
4. Four hundred intermediate girls versus 395 intermediate boys mentioned learning or doing science.
5. No intermediate level teachers mentioned that students wished to learn about or receive training in a science-oriented career. On the other hand, 30 percent or 883 of the intermediate students cited a desire for knowledge or training in a science-oriented career.
6. Four hundred and thirty intermediate girls versus 453 intermediate boys mentioned science-oriented careers.

EFFECT OF AN INSERVICE PROGRAM ON THE ATTITUDE OF JUNIOR HIGH SCHOOL SCIENCE TEACHERS AND THE RELATION OF THIS ATTITUDE TO STUDENT ACHIEVEMENT

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Junior high school students are at a level of cognitive development in which they would benefit from instructional strategies which emphasize active laboratory participation as the mode for learning science. Consequently, junior high school science teachers by improving instructional strategies which emphasize active laboratory participation could facilitate student learning. An inservice program could provide an opportunity for junior high school science teachers to update their instructional strategies for teaching science.

A one-day inservice program for junior high school science teachers was designed stressing selected instructional strategies. An important purpose of this inservice program was to enhance teacher attitude toward the selected strategies while improving their instructional skills with these strategies. It was postulated that this teacher attitude toward certain instructional strategies could relate to student achievement in the concepts and processes of science.

The purpose of this study was to ascertain if there was a relationship between participation in an inservice program and a teacher's attitude toward the instructional strategies emphasized by the inservice program. Second, the study was to determine if there was a relationship between this attitude and student achievement in the concepts and processes of science.

Thirty-five junior high school science teachers for grades seven and eight in two suburban school districts were the sample for this study. Fifteen teachers participated in a one-day inservice program and 20 teachers served as a control group. All teachers completed a semantic differential concerning their attitude toward the instructional strategies emphasized in the inservice at the beginning of the study and after a six-week experimental period. Two thousand five hundred and forty-five students of these teachers were both pre and posttested on a science achievement test focused on the concepts and processes of science. The students were also academically grouped into quartiles based on a standardized achievement test. For the analysis the teachers received the mean achievement score for their students in each quartile.

The results of the study indicated a positive relationship between teacher participation in the inservice program and teacher attitude toward the strategies emphasized in the inservice program. Also, there was a direct and positive relationship between this attitude and student achievement in the concepts and processes of science.

The findings of this study indicate the importance of carefully designed inservice programs. Although the inservice program in this study was only for one day, it did have an impact which is relevant of teachers and to the achievement of their students in science.

CONCURRENT SESSION E

Session E-3 Instruction

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The Science Role Concepts and Dogmatism of Preservice Elementary Teachers

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The Effects of Teachers' Cognitive Questioning Level and Redirecting on Student Science Achievement

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The Effect of An Extended Teacher Wait-Time on Science Achievement in Australian School

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THE SCIENCE ROLE CONCEPTS AND DOGMATISM OF PRE-SERVICE ELEMENTARY TEACHERS

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The study was undertaken in an attempt to answer the following questions: Are the science role concepts of a prospective teacher at the completion of a non-field based science methods course significantly related to the science role concepts exhibited by the instructor of the course? Are the science role concepts of a prospective teacher at the completion of a field based science methods course significantly related to the science role concepts of the methods course instructor or the cooperating teacher? Is there an extant significant relationship between a prospective teacher's science role concepts and degree of dogmatism?

Seven sections of students (N = 139) in a science methods course served as subjects for the study. The sample consisted of two groups of students in a non-field based program and five sections of students in field based programs. In addition, elementary school cooperating teachers (N = 90) who worked with students in the field based programs and four science methods course instructors also provided data for the study. The prospective teachers were administered in a pretest-posttest manner instruments which measured their science role concepts and degrees of dogmatism. Cooperating teachers and methods course instructors each took the instruments once. Additional biographical and classificatory data were also collected.

In this study, a person's opinions concerning the appropriateness of science activities, as indicated on a 45-card Q-sort instrument, the Science Class Activity Profile (Greene, 1971, pp. 79-81), was defined to be his science role concept. Rokeach Form E Dogmatism Scale (Rokeach, 1960, p. 90) was used to measure open-closed mindedness. Biographical data were collected by instruments developed by the investigator.

Data analysis involved the application of appropriate parametric and non-parametric tests of significance.

The major findings of the study were as follows:

1. In both non-field and field based science methods sections, the science role concepts of prospective teachers changed significantly in the directions of the science role concepts of the instructors of the sections;
2. In field based science methods sections, the science role concepts of prospective teachers did not change significantly in the directions of the science role concepts of the cooperating teachers of the sections;

3. There were no significant changes in prospective teacher dogmatism during science methods sections;

4. Elementary school cooperating teachers were significantly less dogmatic than elementary school preservice teachers; and

5. There was no significant correlation between prospective teacher degree of dogmatism and science role concept locus of control.

The conclusions of the study were as follows:

1. A preservice elementary school science methods course, if conducted along the lines of the programs in the study, could significantly affect the science role concepts of prospective teachers;

2. Whether in field or non-field based programs, the methods course instructor played a significant role in the formation of prospective teachers' viewpoints concerning the teaching of science;

3. Cooperating teachers, in the field based teacher education programs, did not act as the significant model of elementary school science role concepts for prospective teachers; and

4. The dogmatism of preservice teachers appeared to be a quality resistant to change during the length of a science methods course.

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THE EFFECTS OF TEACHERS' COGNITIVE QUESTIONING LEVEL AND REDIRECTING ON STUDENT SCIENCE ACHIEVEMENT

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Objectives

The objectives of this experimental study were to investigate the effects of high cognitive questions, low cognitive questions and a 50 percent combination of these questions on primary and intermediate students' achievement at the knowledge, comprehension and synthesis levels. A second purpose was to examine the effects of redirecting questions on student achievement.

Theoretical Framework

Correlational studies relating cognitive levels of teachers' questions to student learning show no clear relationship (Rosenshine, 1971; Dunkin and Biddle, 1974). In a report to the National Institute of Education, Winne (1975) was able to find only eight experimental studies investigating this relationship. Of these studies, only one (Buggey, 1971), provided evidence that higher cognitive questions led to improved achievement relative to lower cognitive questions. However, Savage (1972) replicated Buggey's study and was unable to find significant differences in student achievement. Because Buggey used primary students as subjects and Savage used intermediate students, it was suggested that pupils' thoughts at the intermediate level are not as dependent upon the teachers' style of questioning.

The possibility of a relationship between redirected questioning and achievement has tentative support in correlational studies but no previous experimental support.

Methods and Data Sources

Groups of five subjects were randomly selected from 15 intermediate and 15 primary classrooms and then randomly assigned to one of three treatment levels, resulting in an N of 150.

The treatment levels were:

1. high cognitive questions—subjects in the group were taught from a prepared lesson script containing questions judged to be above the knowledge level,
2. low cognitive questions—subjects in this group were taught using a prepared script containing questions judged to be at the knowledge level, and

3. combination—subjects in this group were taught from a script containing 50 percent low and 50 percent high cognitive questions.

Within the three levels the subjects were also randomly assigned to one of two questioning strategies: 1) redirected, and 2) non-redirected. Redirection occurs when the teacher calls on other students (in this case 2) to respond to a question answered by one student.

The content of the 30-minute lesson was the same for each group and was selected from the published minilessons in the Teaching Improvement Kit (Popham, 1972).

Thirty preservice teachers conducted the treatments. The teachers were trained to follow a prescribed behavior pattern and were video taped during the treatment to insure fidelity to the scripted questions. At the end of the lesson a criterion test was administered with three subtests measuring at the knowledge, comprehension and synthesis levels of Bloom's Taxonomy. The instrument was analyzed to insure adequate reliability and validity. This criterion measure served as the dependent variable for a 2 x 2 x 3 factorial analysis of variance (grades x redirection x treatment).

Results

There was no significant difference among scores on the total criterion measure or the subtests due to cognitive questioning level. There was a significant difference due to redirecting questions ($p \leq .03$). Students assigned to teachers using redirection scored significantly higher than those assigned to teachers not using this strategy. This difference was found on the knowledge subtest. None of the possible interactions were determined to be significant.

Importance

The results of this study indicate that student achievement at the knowledge level can be increased by redirecting questions. Previous research has indicated a possible link between redirecting questions and student achievement, however, these studies were exclusively correlational in nature and could not test causality. The results of this study support a cause and effect relationship between redirecting questions and student achievement. The findings also lend support to the increasing evidence that the level of cognitive questioning by teachers apparently has little effect on student achievement.

References

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THE EFFECT OF AN EXTENDED TEACHER WAIT-TIME ON SCIENCE ACHIEVEMENT IN AUSTRALIAN SCHOOLS

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Objectives and Rationale

This study investigated the effect of an extended teacher wait-time on science achievement. Teacher wait-time was defined as the length of the pause preceding any teacher utterance.

The study differed from prior wait-time studies in that:

1. science achievement was the dependent variable.
2. a modified definition of wait-time was used.

The two questions addressed in the study were:

1. Is achievement higher when instruction incorporates a teacher wait-time greater than a threshhold of 2.7 seconds?
2. Does the use of an extended teacher wait-time lead to higher achievement for children at the formal stage over those at the concrete stage of cognitive development?

Methodology and Design

The sample consisted of 23 intact classes of children from grades 5, 6 and 7 in Australian schools.

A blocking technique was used to pair schools so that variables such as school size and the number of participating classes in a school could be controlled. Schools from each blocked pair were randomly assigned to the two treatment groups. During the treatment phase one group of teachers endeavored to extend their wait-time beyond three seconds while the other group maintained a wait-time between 0.5 seconds and 1.0 second. In fact, three treatment groups were defined because some teachers in the extended wait-time group could not attain a mean wait-time above 2.7 seconds. These groups which constituted the treatments of a quasi-experimental design were:

1. wait-time greater than 2.7 seconds (n = 8).
2. wait-time greater than 1.0 seconds but less than 2.7 seconds (n = 5).
3. wait-time less than or equal to 1.0 second (n = 10).

Science achievement was measured on three occasions:

1. a pre-test administered prior to the treatment phase.

2. a post-test administered midway through the treatment phase.
3. a post-test administered at the conclusion of the treatment phase.

Children were categorized as concrete or formal on the basis of performance on a paper and pencil test administered after the final achievement test. The sample used in the analysis of question two consisted of all children categorized as formal (approximately 5 percent) and a random selection of children at the concrete stage. The selection process ensured that the number of formal and concrete subjects from each class was equal.

Instruments and Data

Science achievement was measured with paper and pencil tests based on physical science concepts taught in the study. Reliability coefficients for each of the tests ranged from 0.6 to 0.7.

To identify children at the formal operational level a test devised by Tisher and Dale (1975) was modified. A validation study compared performance on the modified test with performance on three Piagetian tasks ($\phi = 0.6$, $p \leq 0.001$).

Results and Conclusions

1. A statistical analysis for the first question was based on class mean scores. A repeated measures ANOVA showed significantly higher achievement by the extended wait-time group ($p \leq 0.007$) over the other groups on each post-test. A similar analysis based on gain scores suggested that the effect of using an increased wait-time was cumulative. The gain from the pre-test to post-test 1 was not significant ($p \leq 0.08$) while the gain from the pre-test to post-test 2 was significant ($p \leq 0.04$). Each of the analyses failed to show significant differences in achievement between the shorter wait-time groups. These findings suggest the existence of a wait-time threshhold near 2.7 seconds.

2. The statistical analysis for the second question used individual scores as the unit for analysis. A repeated measures ANOVA, with cognitive development as a stratifying independent variable indicated that there was not a significant interaction between wait-time and cognitive development. The use of an extended teacher wait-time did not alter the relative achievement of children at the formal stage compared with those at the concrete stage. The analysis of main effects confirmed the results of the analysis for question one. The use of an extended wait-time was as effective for concrete thinkers as for children able to use formal operations.

Reference

Tisher, R. P. and L. G. Dale. *Understanding in Science Test*. Hawthorn, Victoria: Australian Council for Educational Research, 1975 (Experimental edition).

CONCURRENT SESSION E

Session E-4 Techniques and Procedures of Research

Topic: Principal Components and Profile Analysis--
An Introduction and Work Session

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A training session involving the use of principle component analysis to detect common components or attributes of a series of data, and the use of profile analyses as an alternative both mathematically and graphically to multi-variate analysis of variance is proposed. In this session, participants will not be required to have statistical backgrounds beyond that of analysis of variance and simple linear regression. The proposed training session will be at a practitioner's level, with the mathematical calculations presented as a black box in computer programs (such as BIOMED SPSS and MIDAS) found at major educational institutions throughout the country. Interpretation of sample data will be carried out during the session so participants will have practice in interpretation as well as theory.

CONCURRENT SESSION E

Session E-5 Paper Set: Teaching Procedures

Presiding:
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Concrete and Formal Instruction

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and

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The Influence of Inquiry Learning on Intellectual Development, Achievement, and Intelligence Quotient

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and

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Group Experience and Solving Science Problems

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CONCRETE AND FORMAL INSTRUCTION

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Research was conducted to compare the effectiveness of thorough explanations of selected science concepts with the student interacting with materials related to those concepts. The effectiveness of each instructional methodology was judged by the students' content achievement, IQ level changes, and gains in intellectual development.

Methodology

Two distinctly different instructional methodologies were employed with ninth grade physical science students. Each of two groups experienced the same concrete operational concepts from the content units: Static Electricity, Current Electricity, Light and Optics, and Sound.

The classroom procedure used with one group clearly presented in a logical sequence those facts, principles and data needed to enable students to be thoroughly exposed to a concept and was labeled formal instruction. It consisted of oral explanation sessions, motion pictures and filmstrips, textbook readings, questions and problems, supervised study, and demonstrations. The students were told exactly what they were expected to know.

The contrasting classroom procedure used with the other group was based upon the Learning Cycle (Renner, 1973) and labeled concrete instruction. It consisted of three distinct, sequenced phases: Exploration, where learners are allowed to gather data and develop understanding of a concept through actual first-hand experience; Conceptual Invention, where learners acquire language of the concept; and Discovery, where learners are led to expand their mental structures or systems of transformation (Piaget, 1971). The students were not told what they were expected to know.

Both groups were evaluated on their content achievement by their responses on multiple choice and free response examinations at the end of each content unit and again three months later. They were evaluated on IQ level, immediately prior to and following the classroom instruction using the Short Form Test of Academic Aptitude, Level 5 (Sullivan, 1970). Their intellectual development was measured immediately prior to, following, and three months after the classroom instruction using four Piagetian tasks (Inhelder, 1958): Conservation of Volume, Separation of Variables, Equilibrium in the Balance, and Combinations of Colorless Chemical Liquids.

Results

Content Achievement. In three of the four content units the concrete instruction group significantly outscored the formal instruction group on the end-of-unit examinations. Both groups were victims of forgetting when retested three months later, however, in all cases the concrete instruction group significantly outscored the formal instruction group.

Intellectual Development. During the classroom instruction period the concrete instruction group showed significantly greater gains measured by the Piagetian tasks than did the formal instruction group. During the next three months, when the classes experienced their regular science program, no significant intellectual development gains between the two groups were evident.

Student IQ. During the classroom instruction the two groups showed no significant difference in IQ gains.

General Conclusions

The striking gains in content-achievement and the retention of those gains made by the group experiencing concrete instruction over the group experiencing formal instruction strongly indicate that actual first-hand experience with objects, situations and/or events builds the mental structures necessary to function with a science concept. The gains in intellectual development indicate that the concrete instruction methodology is superior to the formal instruction methodology in promoting intellectual development. The implication for educators concerned with promoting the acquisition of science content and/or intellectual development is that the actual first-hand experience of concrete instruction should replace formal instruction techniques where they are currently being used.

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THE INFLUENCE OF INQUIRY LEARNING ON INTELLECTUAL DEVELOPMENT, ACHIEVEMENT, AND INTELLIGENCE QUOTIENT

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This study was concerned with 1) investigating the effect of the inquiry treatment on intellectual development, content achievement, inquiry skills achievement, and intelligence quotient, and 2) examining the relationships among these four parameters.

The experimental treatment employed in this research was the Inquiry Role Approach program developed for high school biology by the Mid-continent Regional Educational Laboratories. A random sample of 92 subjects from a midwestern high school was pretested to determine cognitive developmental level, achievement in biology content and inquiry skills, and IQ. At the conclusion of the experimental treatment the subjects were posttested.

Examination of the data indicate that 1) the inquiry teaching methodology does promote cognitive development, increases content achievement, enhances inquiry skills achievement, and produces gains in IQ scores and 2) correlations of varying degrees do exist among those four parameters. These results necessitate an assessment of current curricula development and implementation.

GROUP EXPERIENCE AND SOLVING SCIENCE PROBLEMS

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Rationale and Statement of the Problem

According to the intellectual development model of Piaget, social interaction is one of the fundamental factors by which an individual moves from one intellectual stage to another. Do students who socially interact with one another and who may be in situations which provide greater opportunity for cognitive conflict give responses of a higher quality to problems than students who have not had this opportunity? This research investigated whether the quality of responses given by groups of students to two science problems differed from responses given by individual students to the same problems. Other factors which may be related to solving problems were also investigated. These factors were previous experience in working in groups, degree of intellectual heterogeneity within the groups, level of intellectual development and grade.

Sample, Results and Interpretation

Students from the tenth grade who were studying a biology course organized with group work formed the sample of groups with prior group experience. Other groups of students were formed in which the students had not had such extensive group experience. Also students who solved the problems individually had not had extended group activities.

Two science problems were given to individuals and groups of students. These problems required written free-response answers. The level of intellectual development was determined for each student before they interacted with the problem. The four students in each group from grades ten, eleven and twelve were asked to give their group's solution to both problems. Intellectually homogeneous and intellectually heterogeneous groups were used.

A hierarchy of responses was developed for each problem by a team of four persons, each of whom had had nearly one year of experience developing such hierarchical scales. The responses of each participant in this research were then evaluated using these hierarchies. Two evaluators evaluated each participant and a 90 percent agreement among the evaluators was achieved on all evaluations.

The within groups and between group data were statistically treated with two-way analysis of variance and t-tests as appropriate to test the hypothesis of no differences between group and individual performances.

Statistical tests showed that groups with previous group experience scored significantly higher on both problems than groups without previous experience. When groups who had prior group experience were compared with individuals from the same grade without previous group experience, a one-tailed t-test showed that the groups scored significantly higher than the individuals on both problems.

Intellectually heterogeneous groups provided significantly higher quality solutions on one problem but not on the other. Students in these groups had not had planned group experiences.

These results show that when students have organized group experiences, groups of them produce a higher academic achievement than do individuals. Furthermore, when groups are made of individuals who are working together for the first time that group's performance is below groups made up of individuals who have had group experience. These data suggest that the factor of social interaction is important in the educative process and the effects of the interaction are cumulative.

CONCURRENT SESSION F

Session F-1 Paper Set: Video Cassettes in College Science

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Explanation of Student Use of Supplemental Videocassettes in Large College Classes Using Multivariate Techniques

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The Effect of Supplemental Videocassette Lectures on Student Achievement in Large College Classes

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EXPLANATION OF STUDENT USE OF SUPPLEMENTAL VIDEOCASSETTES IN LARGE COLLEGE CLASSES USING MULTIVARIATE TECHNIQUES

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In this study, students enrolled in three large lecture introductory biological science courses had access to videocassette lectures as either supplements or alternatives to live lecture. The tapes were maintained in the university library and were available to the students upon demand. When the tapes were checked out, students were required to fill out a checkout slip. Consequently, a record of the number of tapes viewed per student was available for research purposes. In addition, variables relating to ability, science background, and selected personality traits were obtained for each student.

Research carried out on the data collected from the past academic year has indicated a strong, positive relationship between student performance (grade earned) and the frequency of student use of videocassette lectures. Multiple regression and discriminant analyses have shown that frequency of tape viewing contributes significantly to the explanation of achievement above that contributed by the ability, background, and personality variables.

Because of this strong, unique relationship between frequency of tape viewing and student achievement, the explanation of videocassette lecture usage is a significant research question. If the variance in tape usage between students can be explained by ability, background, and personality variables, then tape viewing has potential as a moderating or compensatory variable. Questions such as "do students with poorer science backgrounds view tapes more frequently?"; or "do highly test anxious students view tapes more frequently?"; or "do lower ability students view tapes more frequently?", can be addressed.

This paper discusses the initial effort to explain the variance in tape usage and the role of tape usage as a moderator variable in individual differences models. Multiple regression and path analysis were used to determine the relationship between the following variables: Minnesota Scholastic Aptitude Test (MSAT) scores; the number of units of high school biology, chemistry, and physics (HSCI); test anxiety (TAQ); the number of tape views (TV), and grade earned (GRADE). Multiple regression equations were generated separately for each gender in each of three different courses. One set of regressions used GRADE as the dependent variable and MSAT, HSCI, TAQ, and TV as the independent variables; a second set of regression equations used TV as the dependent variable and MSAT, HSCI, and TAQ as the independent variables.

Results from the initial analyses showed that all regression equations using GRADE as the dependent variable were highly significant, while the regression equations using TV as the dependent variable were not significant. These results were supported by the resulting path analysis models. Thus, based on this initial effort, it would appear that the explanation of tape viewing is complex and requires further research. This is presently being done on data from the current academic year and the results of these analyses will be discussed.

Note

Work partially funded by a grant from the National Science Foundation CAUSE Program, SER 76-16100.

THE EFFECT OF SUPPLEMENTAL VIDEOCASSETTE LECTURES ON STUDENT ACHIEVEMENT IN LARGE COLLEGE CLASSES

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Many college students take courses in the biological sciences to fulfill general education requirements for a baccalaureate degree. Students of diverse interests and backgrounds, mixed in large lecture classes, present unique pedagogical problems and challenge the instructor to devise instructional strategies which will provide for individual differences. During the last two years, we have arrived at a strategy that seems to allow for these differences. The solution has involved two developments: implementation of a self-paced testing program and creation of supplemental videocassette lectures. The effect of the latter on student achievement (grade) is the subject of this paper.

Over 130 videocassette lectures have been developed as a supplement or alternative to live lectures in three introductory biological science courses. The video-tapes were made in commercial television studios by experienced course instructors using highly visually-oriented techniques. The videocassettes are available to students on a demand basis through a viewing center established in the university library. Last year 5,500 students enrolled in these courses and over 33,000 uses of the cassette collection were recorded. On the average, six uses per student occurred, though many students viewed more while others viewed none. The video-lectures serve many purposes. They may be used as advanced organizers of lecture, as a means of review, or to replace live lectures missed for personal reasons. Use is according to student reasons, since the live lecture continues and viewing is not required. Students who use the video-tapes overwhelmingly agree that the tapes are a useful learning aid, though some would disagree.

In addition to these curriculum developments, a research project is underway to determine what effects videocassette viewing has on achievement. The central question is, "what types of students profit most?" Correlation analysis has shown that frequency of cassette viewing is related positively to high school science background, ability, and grade earned in the courses. From this, one might conclude that only the better students profit from this form of instruction. Multiple regression analysis (step-wise), however, demonstrates that use of videocassettes contributes uniquely (R^2 values 2 percent to 11 percent) to grade earned in the course in addition to background and simple regressions of grade as a function of frequency of videocassette viewing are performed. All four groups profit from viewing tapes. We have also found that videocassette viewing is not associated with missing classes or reduced time spent in studying texts or notes. Students who view videocassettes simply spend more time.

These results are still of a preliminary nature, but we feel that they demonstrate that through television it is possible to provide for individual differences within the large lecture format. Future analyses will look at the effects of the interaction of self-paced testing and videocassette viewing on student achievement and will also seek to explain what variables predict student use of videocassettes.

Note

Work partially funded by a grant from the National Science Foundation CAUSE Program, SER 76-16100.

CONCURRENT SESSION F

Session F-2 General Research

Presiding:
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The Relationship Among Intellectual Development, Achievement and Self-Concept of Elementary School Minority Children

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Can Information About Famous Black Scientists Influence the Self-Concept and Academic Achievement of Elementary Minority School Children?

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The Development and Validation of the Image of Science and Scientist Scale

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THE RELATIONSHIP AMONG INTELLECTUAL DEVELOPMENT, ACHIEVEMENT, AND SELF-CONCEPT OF ELEMENTARY SCHOOL MINORITY CHILDREN

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A review of the research literature reveals that there has been a sharp increase in the number of studies linking self-concept to academic achievement. It is believed that one of the major reasons for the lack of success among minority students, such as Blacks and Hispanics, is that these students appear to possess lower self-concepts than students from other ethnic backgrounds. Reyes (1976) suggests, in the case of minority students, that a culturally relevant curriculum with serious consideration of a child's self-concept is necessary to insure academic success. Research studies by Caplin (1966) and Godfrey (1970) support the contention of a strong relationship between self-concept and academic achievement of minority students.

The purpose of this study was to determine if there is a relationship between self-concept and academic achievement among minority (black and hispanic) students. In addition, the study considered intellectual development as a variable that could be related to self-concept. The 51 subjects in this study were second grade children in a predominantly bi-ethnic (black and hispanic) school. The study was conducted during the 1977-78 academic year. The Piers-Harris Self-Concept Scale was used to measure self-concept. Academic achievement was measured through the use of the Stanford Achievement Test (Primary Level, Form A, 1972), and intellectual development was assessed using an instrument composed of seven Piaget-like tasks. Data were analyzed by calculating Pearson product-moment correlation coefficients.

Examination of the correlation coefficients indicated that there are positive correlations between self-concept and the Stanford Achievement Test subscales: Reading A ($p \leq .001$); Reading B ($p \leq .001$); Social Studies ($p \leq .05$); Science ($p \leq .001$); and Listening Comprehension ($p \leq .05$). In addition, positive correlations were found between self-concept and the following four Piaget-like tasks: 1) Length (response and explanation, $p \leq .05$); 2) Area (explanation, $p \leq .05$); 3) Weight (explanation, $p \leq .05$); and 4) Volume (explanation, $p \leq .05$).

The results of this study support the belief that in considering the teaching of minority students, in particular, it is imperative that consideration be given to the development of a positive self-concept. Practically, this may be translated into the planning and development of curriculum materials and methods that are conducive towards reaching this goal.

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CAN INFORMATION ABOUT FAMOUS BLACK SCIENTISTS INFLUENCE THE SELF-CONCEPT AND ACADEMIC ACHIEVEMENT OF ELEMENTARY MINORITY SCHOOL CHILDREN

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Perennial problems facing educators are those of developing curriculum materials and pedagogic methods which can be shown to have effects on self-concept and academic achievement of minority elementary school children. It is important to do this since there is some research evidence which shows that these students do not fare as well as other students on the traditional standardized tests, for a variety of reasons. A review of the research literature tends to confirm the contention of a strong relationship between self-concept and academic achievement of minority students. Caplin (1966) found that Black elementary school children who had more positive self-concepts tended to also have higher academic achievement scores. The same results were obtained by Godfrey (1970) in his study of Black students enrolled in North Carolina public schools.

The purpose of this study was to determine if the teaching of famous Black scientists would influence the self-concept and academic achievement of minority elementary school children.

The subjects in this study consisted of 77 second grade minority school students. These students were assigned to three groups. One group was taught the Individualized Science (IS) materials, plus information on Black scientists. A second group was taught only the IS materials, and a third group was taught science based on a traditional approach. The treatment lasted for seven months. Academic achievement was measured by administering pre- and post-tests of the Stanford Achievement Test, Form A. The Pier-Harris Self-Concept Scale was used to gather data to measure self-concept scores.

A multivariate analysis of covariance revealed that the IS plus Black scientist group did significantly better than the IS only group on the Stanford Achievement Test subscales Reading A ($p \leq .05$), and Social Studies ($p \leq .05$). In addition, the data revealed that the IS plus Black scientist and the IS only groups pooled performed significantly better than the traditional group on self-concept ($p \leq .001$); Stanford Achievement Test subscales Social Studies ($p \leq .05$) and Science ($p \leq .05$). The analysis also showed a strong relationship between subjects pre- and post-tests, and it was shown that the test of equality of regression was not significant.

The results of this study showed that although commercially produced science curriculum materials are effective in enhancing the self-concept and academic achievement of minority students, it additionally suggests that information on Black scientists can produce a greater gain. This is a clear signal to curriculum developers and teachers to include information about minority scientists when teaching science to these students.

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THE DEVELOPMENT AND VALIDATION OF THE IMAGE OF SCIENCE AND SCIENTISTS SCALE

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In 1957, Margaret Mead and Rhoda Metraux reported the results of a nation-wide study that investigated the image of the scientist as held by secondary school students. The timing of the study was of particular interest since it occurred just before the science curriculum "boom" and the most technologically oriented era in history. The question posed by this investigator was, "Had those years of technological and academic change influenced the image of the scientist?" In order to investigate this question, it was necessary to develop an instrument based on the aforementioned study.

Method

The Image of Science and Scientists Scale (ISSS) was originally composed of 50 items, 25 positive and 25 negative, with an agree/disagree format. It was administered to a randomly selected sample of seven through twelfth graders (N = 388). It was also given to two criterion groups composed of 56 science teachers and 36 science-oriented twelfth graders. Upon analysis of the data, two items were deleted and the format was changed to a six-point Likert-type scale. It was then readministered to 251 ninth graders.

Results

The initial testing phase yielded a reliability coefficient of .79 using the Kuder-Richardson 20 formula. In the second phase, the reliability increased to .86. Construct validity was established using the known groups method as suggested by Kerlinger (1964). In both phases the sample was compared to the criterion group and, as expected, the science-oriented group scored significantly higher, indicating that the instrument measured a unique quality. This result was obtained even when IQ's were controlled.

During the second phase of the validation process the relationship of science grades to the results of the image scale was also examined as another indicator of the instrument's validity. A multiple stepwise regression analysis was performed with science grades as the dependent variable and non-verbal IQ, verbal IQ, and science attitude (image) as the independent variables. Both verbal and non-verbal IQ had a significant effect on grades in science ($p \leq 0.01$), as might be expected. What is interesting, however, is science attitude also significantly influenced student's grades in science ($p \leq 0.01$). This is a strong indication that the instrument measures science attitude, since logically someone who has a more positive attitude toward the subject matter would be expected to do better (grade-wise) than students who do not, given the same level of intelligence.

Conclusion

The results of the validity analysis indicate that the ISSS: 1) does discriminate between groups that one would expect to have differing attitude toward science, and 2) does contribute to the prediction of science achievement in addition to IQ. The ISSS then, may be useful to those interested in assessing high school attitudes toward the field of science.

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CONCURRENT SESSION F

Session F-3 Techniques and Procedures of Research

Topic: Assessing Teacher Performances

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The purpose of this training session is to help science educators learn a procedure for assessing teaching performance or competence. Being able to objectively assess the performance or skills of teachers can aid in studies of teacher behavior, program evaluation, and preservice or inservice teacher education. The 18 competencies included in the assessment are associated with six teaching functions: planning, instructing, managing, providing the learning environment, evaluating, and being a professional. Extensive tryouts have shown the teacher competencies and assessment procedures to be valid and reliable. Videotape analysis, examination of teaching objectives and procedures, and discussion will be used to teach participants how to use this competency assessment system.

CONCURRENT SESSION F

Session F-4 Research Methodology

Presiding:

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A Search for the Processes of Science

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A Meta-Analysis of Elementary School Science Process-Curricula Evaluation Studies

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A Meta-Analysis of Selected Advance Organizer Research Reports from 1960-1977

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A SEARCH FOR THE PROCESSES OF SCIENCE

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Objectives

This investigation involved data which was generated in the developmental study for the Television Test of Science Processes (TTSP) of the Science for the Seventies ITV resource. Several questions were posed regarding the identity and uniqueness of those cognitive activities called processes of science. The problem was: Could unique relationships be found among the various data to isolate unique or mutually exclusive skills and abilities?

Theoretical Rationale

National curriculum projects and some research undergird the perceived value of teaching science processes. Ambiguity of definition and enumeration among educators and failure of attempts to derive unique subscores for specific processes by test developers suggested a need to further examine the body of data generated within the TTSP study.

Methodology

Two hundred fifteen fifth grade students of a Pennsylvania school system were coded and scores of their performance on 15 variables were recorded on a data matrix. Data processed at the Computer Center of the Pennsylvania State University using the Pearson Product-moment Correlation and the Factor Analysis of the Statistical Package Program.

Pearson product-moment intercorrelations were computed for all variables and then factor analyzed using the principal components program, Fanal. Iterations were continued until a criterion of 1 percent of the total variance was met. In addition, factors were rotated to simple structure using the Varimax program.

Data Sources

Variables included:

1. the total score of the Television Test of Science Processes,
2. scores of those questions within the TTSP identified by Tannenbaum as classification questions,
3. the total score of The Science Process Test,

4. the time in minutes required by the students to take *The Science Process Test*,

5. the verbal score of the *Short Form Test of Academic Aptitude* (SFTAA),

6. the nonverbal score of the SFTAA,

7. the weighted total score of the SFTAA,

8. the reading vocabulary of the *Comprehensive Test of Basic Skills* (CTBS),

9. the reading comprehension score of the CTBS,

10. the weighted language total score of the CTBS,

11. the math score of the CTBS,

12. the science score of the CTBS,

13. the social studies score of the CTBS,

14. the science grade on the mid-year report card, and

15. the Otis-Lenon I.Q.

Findings

Two factors were found. A summary of the factor analysis shows all variables except 2 and 4 have high factor loadings on Factor 1. In addition, Factors 2 and 4 are defined by one variable only and the variables that define Factors 2 and 4 are different. Therefore, it appears that all the variables assess one strong general factor.

Factor 1 accounts for 65.71 percent of the trace on the Principle Component Analysis. It could be inferred that approximately two-thirds of the variance of the measures of science processes can be accounted for by intelligence, reading ability, general achievement, etc. Possibly the characteristic being assessed in science process tests simply reflects general problem solving ability. Also, the unique skills and abilities identified as the processes of observing, comparing, measuring, etc., are not totally unique or mutually exclusive.

Educational Significance

A conclusion can be drawn that there is no unified definition or enumeration of those separate and semantically identifiable processes. Also, the validity of a test instrument designed to measure a student's performance in his ability to use those processes must, in the absence of an empirically unique characteristic, rely heavily on face or content validity. A measure of the unique process ability or characteristic rests to a large degree on inferences derived empirically from data which suggests performance on characteristics which are similar and generalizable within the perimeters of an accepted definition.

A META-ANALYSIS OF ELEMENTARY SCHOOL SCIENCE PROCESS-CURRICULA EVALUATION STUDIES

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For more than a decade several science curriculum programs produced through federal funding have been widely used in American elementary schools. The effectiveness of these programs has been evaluated in more than 60 individual evaluation studies which have been reported in the literature in the form of dissertations and published articles. Even a cursory look at a few of the studies reveals considerable variation in population, methodology, outcomes measured and findings. The purpose of the present study was to assess the general effectiveness of these curricula using meta-analysis techniques (Glass, 1976) and to explore some of the relationships between selected evaluation study characteristics and their findings. The three programs selected for evaluation were The Elementary Science Study (ESS), Science A Process Approach (SAPA) and the Science Curriculum Improvement Study (SCIS). These programs which are reported to be used in one form or another by approximately one-third of the nation's elementary school children represent a major departure from the traditional, science facts and principles, curricula. They emphasize enquiry and problem solving objectives and employ heavy use of manipulatives and laboratory activities in the classroom.

Method

Each reported evaluation study of the three major, federally funded elementary science curriculum projects—Elementary Science Study (ESS), Science A Process Approach (SAPA), and Science Curriculum Improvement Study (SCIS)—which used a control group was coded on 32 variables relating to population, treatment, design, outcome measures, analysis and findings. A pairwise comparison of experimental and control group at a single grade level and for an outcome instrument subscale constituted a unit of analysis. Over 300 such pairwise comparisons were analyzed. The dependent measures of the meta-analysis included t values, effect size—$(\bar{x}_1 - \bar{x}_2)/s$—and strength of association (w^2). Outcome measures were categorized into six sub-areas: creativity, affect, cognitive-non-science, cognitive-general, cognitive-science-content and cognitive-science-process. Outcome sub-areas were analyzed separately.

As indicated in the table below, outcome measures of science processes showed an advantage of nearly three-fourths of a standard deviation, although process curriculums showed almost no advantage in cognitive-non-science and cognitive-science content measures as indicated by effect size.

Table of Meta Analysis Results

Outcome Measures	Number of Comparisons	Mean No. Subjects	Mean Effect Size
Creativity	36	27	.32
Affect	22	174	.15
Cognitive-Non-Science	41	82	.06
Cognitive-General	29	68	.20
Cognitive-Science Content	19	177	.07
Cognitive-Science Process	108	126	.73

These results are consistent with what is generally accepted as the advantage for process curriculums. Processes and to a lesser extent creativity, general cognitive abilities and affect are advanced by such curricula, although learning of non-science objectives and science content in the form of facts and principles are not generally improved or hindered by them. This suggests that in choosing these curricula a choice of educational priorities is made.

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A META-ANALYSIS OF SELECTED ADVANCE ORGANIZER RESEARCH REPORTS FROM 1960-1977

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This is a report of a meta-analysis of selected advance organizer research reports. The study was undertaken because of the large amount of research in this area, and the general failure to reach any definitive conclusions from this research. The purpose of the analysis was to determine whether or not there were any characteristics of the experimental settings or materials in the 99 advance organizer studies analyzed that had consistent relationships with the treatment effects obtained through the use of advance organizers. The dependent variables used to represent the treatment effects were the t-statistic for the difference between means and the probability level of significance. The independent variables described characteristics of the sample, treatment administration conditions, type of subject matter, quality of the research procedures, and characteristics of the advance organizers and learning materials.

The data analysis involved the computation of descriptive statistics, the examination of the relationships between independent and dependent variables by correlation coefficients and stepwise multiple regression analysis, and the examination of the interrelationships among the independent variables by factor analysis.

Of the 99 t-statistics computed, 68 were positive. Nine of these were significant at the 0.05 level and 13 were significant at the 0.01 level. None of the 29 negative t-statistics were significant. These results indicate that there is a tendency for advance organizers to show facilitative effects.

Some of the significant findings in favor of advance organizers may have been due to the possible contribution of the advance organizer alone to answering the test questions or to an inequality of study time for the treatment groups. The influences of these variables on the relationships between the dependent and independent variables were removed by stepwise multiple regression analyses.

The relationship between type of advance organizer and the dependent variables was probably the most fundamental relationship identified. There was an indication that comparative advance organizers may be more effective than expository ones.

Student inability to understand the advance organizer information may account for some of the non-significant experimental findings.

There was an indication that advance organizers may become less effective as the learning materials become more complex.

The dependent variables had significant correlations with subject area, concept type, and grade level indicating that advance organizers may be less effective when the subject matter is science, more effective for classificational concepts, and more effective at the higher grade levels. A list of guidelines for future research on advance organizers was reported based on this analysis.

CONCURRENT SESSION F

Session F-5 Piagetian Research

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A Search for Piagetian Stages of Intellectual Development

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Memory for Causal Explanations in Science and Piagetian Operational Levels

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An Investigation of Piaget's Infralogical Groupings Concerning Projective and Euclidean Space

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A SEARCH FOR PIAGETIAN STAGES OF INTELLECTUAL DEVELOPMENT

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The concept of stages of intellectual development continues to be a controversial issue despite its central position in Piaget's theory and its common usage in the research literature. A common assertion is that the continuity-discontinuity issue is incapable of being empirically tested and stages are only reflections of a methodological problem that results from the way developmental data are treated (Belin, 1971). Novak (1977) lists six inconsistencies of the stage concept and states that the concept must eventually be abandoned. On the other hand, Epstein (1978) cites the work of other researchers and provides data in support of stages and the existence of at least one more stage beyond Piaget's formal operational (III b) stage.

The purpose of this study was to search for stages, and to investigate the claim that at least one more stage exists beyond Piaget's formal operational stage. The rationale was that information concerning the existence or non-existence of stages was important because many of the implications of Piaget's theory for teaching science were based on the concept of stage. Both theory and practice in science education could benefit from the resolution of controversies surrounding Piagetian stages.

The data for this study came from research reported by Dale (1970) and DeLuca (1978). Dale's data were based on the performance of 200 students, aged 6 to 15 years, on Piaget's first chemical experiment. DeLuca's data came from a study of 358 students, aged 9 to 18 years, on six Piagetian tasks: conservation of area, weight and volume (clay and cylinders), control of variables (rods), and combinatorial reasoning (electronic task).

Cluster analysis of data on age, gender, and task scores supported the following results and conclusions:

1. Piagetian stages of intellectual development exist as an "average" sequence through which children progress from childhood to adolescence.
2. Deviations from an "average" sequence of development are related to gender and type of task.
3. Males conform to Piaget's stages more so than do females.
4. The greatest deviation from an "average" sequence occurs with females on the control of variables task (rods).
5. The 13-year old females tended to cluster with the 16, 17 and 18-year old females. This anomalously high performance coincides with normative data on the average menarcheal age and the average age for a major growth spurt of the brain.

6. Cluster analysis of data on individual tasks result in dendrographs which show substages IIa, IIb, IIIa and IIIb; but when data from all tasks are subjected to cluster analysis, the resulting dendograph shows that the substages tend to merge into two main stages, II and III. This appears to result from lack of precise synchronization of stages across several tasks, and it also helps to explain the general lack of high intercorrelations among Piagetian tasks.

7. The tendency for 17 and 18-year olds to cluster provides support for a third substage (IIIc) at the formal operational level. The data, however, are equivocal and subject to different interpretations.

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MEMORY FOR CAUSAL EXPLANATIONS IN SCIENCE AND PIAGETIAN OPERATIONAL LEVELS

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A causal explanation of a natural phenomenon can be viewed as a logical chain of implications (if. . .then statements). According to Inhelder and Piaget's (1958) definition of a formal operation, the mental act of chaining implications into an explanation is formal operational because it represents a reversible grouping of propositions into a new coherent structure. In the case of an explanation, the structure has a form somewhat like that of a transitive series: "If A, then B; if B, then C; if C, then D; therefore, if A (the initial condition), then D (the observed outcome" (Inhelder and Piaget, 1958, p. 306).

If explaining is a formal operational task, how will learners who do not generally reason formally assimilate scientific explanations into memory? The purpose of the present study was to investigate the relationship between memory for scientific explanations presented in instruction and operational levels of learners.

Subjects in the study were 26 ninth grade students and 40 college students enrolled in introductory physical science courses. Subjects were first instructed in groups in three 50-minute sessions on air pressure phenomena and their explanations. They were then administered (1) an objective test of knowledge of relevant air pressure principles; (2) a test requiring the writing out of explanations of three of the phenomena, including the egg in the bottle, the candle burning, and the stopper popper experiments described in the Elementary Science Study (1967) unit, Gases and Airs; and (3) four Piagetian-type tasks, which were used in determining operational levels of the subjects. The dependent variable in the study was the number of implication statements that subjects correctly chained together in their attempts to reconstruct the required explanations.

The major findings in the study were:

1. There was no significant difference in the performance of formal and pre-formal subjects on the knowledge of air pressure principles test.
2. Pre-formal subjects were as successful as formal operational subjects in reconstructing an explanation (the stopper popper) involving the chaining of two implications.
3. Pre-formal operational subjects were significantly less successful in reconstructing the more complex explanations requiring the logical chaining of six implications.

The following conclusions were drawn in the study:

1. Reasoning with implications, as required in causal explanations of natural phenomena, is possible for subjects classified as pre-formal operational, as is indicated by the success of the pre-formal subjects with the simpler stopper popper explanation.

2. Explaining more complex phenomena is a formal operational task, not so much because it requires implication reasoning, but because it requires the explainer to operate on the implication statements, combining them into new organizational structures.

3. Pre-formal operational subjects can be expected to have difficulty with more complex explanations, not so much because of the content of the explanations, i.e., the scientific principles required, but because of their form, i.e., the required formal operational chaining of implications.

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AN INVESTIGATION OF PIAGET'S INFRALOGICAL GROUPINGS CONCERNING PROJECTIVE AND EUCLIDEAN SPACE

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Piaget's model of cognitive development suggests that hypothetical mental structures called groupings develop during the concrete operational period. Logical groupings consider the relationships between sets of discrete objects whereas infralogical groupings relate to spatially continuous systems and whole objects. Two types of infralogical groupings—projective and Euclidean—are considered in this investigation. Projective groupings allow subjects to consider objects in relation to a point of view and to understand changes in shape due to perspective changes; Euclidean groupings allow subjects to conserve size, shape and distance as objects are spatially transformed, and enable measurement in two or three dimensions.

The major objective of this research was to examine whether or not a hierarchial relationship existed between scores on six tasks designed to test for the presence of three projective and three Euclidean infralogical groupings. Other objectives investigated were the relationships between task performance, grade level and gender.

The data for this investigation were collected through individual interviews where six Piagetian-type task protocols were presented in a random order to 108 students in grades eight (36), ten (36) and twelve (36). Each task evaluated the presence of a particular grouping; successful completion of the task was believed to indicate that the subject possessed that grouping. The scores from the six tasks were examined for scalability using Chilton's modified scalogram analysis; chi-square tests were conducted to evaluate relationships between task performance, grade level, and gender.

The results of the scalogram analysis indicated that the task scores formed a hierarchy and scaled in an order consistent with that described by Piaget. Statistically significant differences in scores were found at the three grade levels on four of the tasks. All six tasks were passed by more subjects from grade twelve compared to grade ten, and from grade ten compared to grade eight. No task was passed by more than 72 percent of the subjects at a grade level. Statistically significant differences were found between male and female scores on four tasks; in all four instances males scored significantly higher than females.

Many secondary students did not appear to be functioning at the concrete operational level in terms of the projective and Euclidean spatial groupings under examination. During adolescence males appear to possess more highly developed spatial structures than females. It is conjectured that these findings may be a contributing factor to low achievement scores in science and mathematics where subjects such as geometry, physics and certain aspects of chemistry, geology and astronomy involve a significant amount of content related to spatial relations.

CONCURRENT SESSION G

Session G-1 Paper Set: College Laboratory Instruction

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A Comparative Study of Instructor and Student Behaviors and the Role of the Instructor in Introductory and Advanced Laboratories of Five Science Disciplines at the University Level

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A COMPARATIVE STUDY OF INSTRUCTOR AND STUDENT BEHAVIORS AND THE ROLE OF THE INSTRUCTOR IN INTRODUCTORY AND ADVANCED LABORATORIES OF FIVE SCIENCE DISCIPLINES AT THE UNIVERSITY LEVEL

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In 1965, Edmund J. Amidon stated that "what the field of professional education really needs is college teachers who are willing to analyze their teaching and who have the tools to do it" (p. 3). After an extensive review of the literature, it appears as though college science departments have not yet determined how to analyze (even if they should desire to) their own teaching behaviors. Perhaps, this is desirable in that it provides science educators the opportunity to, and the responsibility of, objectively analyzing and reporting classroom and laboratory behaviors to the respective science departments. This study provides the initial groundwork and anticipates future cooperation among science educators and science departments to ensure that students receive, and instructors as facilitators of knowledge provide, the best possible learning environment. An essential aspect of that learning environment is the instructor-student behaviors and interactions.

The purpose of this study was to analyze instructor and student behaviors in introductory and advanced laboratories of five science disciplines at the university level. This study involved two component parts—the development of an interaction analysis system capable of objectively and systematically assessing instructor and student behaviors in college science laboratories; and, the subsequent coding and analysis of such laboratory behaviors in introductory and advanced laboratories of five science laboratories at a major midwest university: botany, chemistry, geology, physics and zoology.

The *Science Laboratory Interaction Categories—Teacher* (Shymansky, Penick, Kelsey and Foster, 1976) and the *Science Laboratory Interaction Categories—Student* (Penick, Shymansky, Filkins and Kyle, 1976) were designed to offer a fresh and much needed attempt to provide accurate and detailed feedback regarding the behaviors and events which take place in science laboratories at the college level.

In carrying out this study, several factors had to be examined in detail. Each of the following will be discussed in our presentation.

A. Development of the Science Laboratory Interaction Categories (SLIC)—Teacher and Student Versions

   1. Instrument validation
   2. Description of the coding instrument

B. Laboratory Observer Training Procedures

C. Data Collection Procedures

   1. The instructor sample
   2. The student sample

D. Methods of Analysis of Collected Data

During the data collection period a total of 84 30-minute instructor observations and 336 10-minute student observations were made. Data collection however, is but a trivial part of any classroom assessment when you consider the problems of using those data to build a valid picture of what was happening in that classroom setting. Thus, a frequency report of each individual instructor and student behavior along with identification of the top 75 three-tally collapsed sequential patterns, i.e., MACRO analysis (Shymansky et al., 1975), was then obtained with a computer program designed to identify behavior patterns in observational data (MACRO 1) (Shymansky, Penick and Wartman, 1977). Thus the complete analysis is based upon behavior scores, i.e., the frequency of occurrence of each individual instructor and student behavior; and, pattern scores, i.e., the mathematical result of the Pattern Analysis Coefficient (Kyle, 1977) for each instructor and student pattern selected.

With the use of instruments such as SLIC and programs for MACRO analysis, much descriptive information can be learned about instructor-student interactions in classroom settings.

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CONCURRENT SESSION G

Session G-2 Elementary Science Instruction

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A Theoretical Model for the Dissemination and Utilization of Knowledge and Its Application to Improving Elementary School Science Instruction

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A Study to Determine the Effect of a Textbook Elementary Science Program Versus a Non-Textbook Elementary Science Program on the Critical Thinking Skill Development of Third Grade Children

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A Suggested Success Model for the Initial Implementation of SCIS in An Urban Setting

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A THEORETICAL MODEL FOR THE DISSEMINATION AND UTILIZATION OF KNOWLEDGE AND ITS APPLICATION TO IMPROVING ELEMENTARY SCHOOL SCIENCE INSTRUCTION

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In the late 1960s, the Pennsylvania Department of Education embarked on an effort to disseminate information about contemporary elementary school science instruction throughout Pennsylvania and assist in the implementation of these new approaches in elementary classrooms. This project, originally entitled Science for the Seventies and later conducted under the designation Investigative Science in Elementary Education (ISEE), initially consisted of a basic curriculum guide and a collection of inquiry-oriented activities.

As the project expanded, a wide variety of additional resources were added to the ISEE program in response to problems that were encountered through interaction with teachers and schools. Included in these expanded resources were a series of instructional television programs designed to introduce classroom lessons activities, a series of instructional television programs structured to provide teacher in-service training, workshops for teachers, special courses for teachers, self-instructional materials for teacher in-service training, materials for integrating science instruction with other subject areas, and a variety of other materials designed for student and/or teacher use.

As the number of identified problems in elementary school science instruction grew and related solutions were designed and developed, a need was perceived for a systematic procedure for identifying instructional problems, relating ISEE resources to these problems as possible solutions, and prescribing the appropriate ISEE resource or resources to help solve a given problem. Furthermore, a procedure was required which would make it possible to disseminate this system throughout a statewide region and assist teachers, schools, and school districts in its use.

Based on careful consideration and analysis of a number of information dissemination and utilization models (with particular attention given to Havelock's Linkage Model) and a variety of communications models, a new theoretical model was designed for the dissemination and utilization of information. This model was assembled for the specific purpose of improving elementary science instruction. An important feature of this model is a computerized data base of information linking instructional problems in elementary science with available solutions.

The model has been piloted, evaluated, and refined in real situations in a number of Pennsylvania school districts. Proposals are currently under consideration to apply the model to other instructional subject areas as well as other geographical regions.

A STUDY TO DETERMINE THE EFFECT OF A TEXTBOOK ELEMENTARY SCIENCE PROGRAM VERSUS A NON-TEXTBOOK ELEMENTARY SCIENCE PROGRAM ON THE CRITICAL THINKING SKILL DEVELOPMENT OF THIRD GRADE CHILDREN

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Objectives and Rationale

The purpose of this study was to compare the influence of two different elementary science programs on the development of critical thinking skills of third grade children. The two science programs utilized in the study were: Concepts in Science (CIS) and Science Curriculum Improvement Study (SCIS).

Most elementary science programs which are currently available to schools espouse the teaching of both the products of science and the processes of science. Emphasis upon teaching the processes of science has been re-vitalized with the advent of activity centered National Science Foundation sponsored programs such as SAPA, SCIS and ESS. These programs have, in turn, influenced developers and publishers of other programs, so that the development of critical thinking skills are included in the major objectives of virtually all elementary science curricula. It remains to be established whether or not certain kinds of elementary science programs are more effective in developing critical thinking skills than others. Basic problem solving abilities are generalizable skills valued in other aspects of the school curriculum and highly regarded as important tools for good citizenship.

Methodology and Design

A pretest-posttest control group design was used for the study. The sample consisted of 188 third grade pupils from four classrooms within two school districts. The experimental group was exposed to the SCIS curriculum, while the control group experienced a textbook program: Concepts In Science. The experimental and control group classes were chosen by socio-economic status, SES, dichotomized as high and low. There were eight intact classes in the study, two high SES and two low SES, for both the experimental and control groups.

Subjects were pretested with the Science Process Instrument (SPI, Weber, 1971) in the Fall of 1976 and posttested in the Spring of

1977 and again posttested in the Spring of 1978. The raw scores on the SPI were compiled as numerical scores for each subject. The numerical scores represented the number of correct responses on the SPI. Six scores were obtained for each subject: one for total instrument and one for each subscale in observing, classifying, measuring, interpreting, and predicting.

Since assumptions for a parametric statistical test were questionable, a nonparametric statistical treatment, Wilcoxon matched-pairs signed-ranks, was chosen.

The subjects were divided, trichotomously, by IQ into high, middle, and low groups. Matched pairs for each IQ group were analyzed using the Wilcoxon test. The Statistical Package for the Social Science (SPSS, Nie, et al.) was used to treat the raw data. The .05 significance level was chosen to test the null hypotheses posited prior to the study.

Instruments and Data

The Cognitive Abilities Test (CAT) was used to place the subjects by IQ into high, middle and low groups. The composite verbal, quantitative, and nonverbal battery scores were utilized for the grouping.

The Science Process Instrument was developed at the University of Oklahoma in order to test elementary school students' levels of performance on the critical thinking skills of observation, classification, measurement, experimentation, interpretation, and prediction. The reliability coefficient for internal consistency was determined by the Rulon split-half method.

The data from the sample yielded a reliability coefficient of 0.64. The instrument's validity was established by asking a panel of science educators to rate each task on the instrument.

Results and Conclusions

Using the SPSS package (version 7) and the nonparametric Wilcoxon test, the posttest and delayed posttest scores for each IQ group were analyzed by total instrument and five subscales.

The SPSS program uses the modified version of the Wilcoxon matched-pairs signed-ranks test (Siegel, 1956, p. 79). The results for the computer program are by positive ranks and negative ranks with a Z-value and associated two-tailed probability.

Mortality and matching reduced the N to a total of 79 pairs for the largest number of comparisons and 33 pairs for the smallest number.

Results revealed that there was a statistically significant difference between the SCIS and the textbook groups on the first posttest for all IQ groups. Only the middle IQ group was statistically significant for the delayed posttest. There was no statistical difference between the SCIS and the textbook groups for low or high IQ on the delayed posttest one year after treatment.

Subscales of the Science Process Instrument were analyzed for the middle IQ group and significant differences were found in favor of the SCIS group.

For the groups participating in this study, it may be concluded that the SCIS curriculum produced greater critical thinking skills than the textbook curriculum for the middle IQ group when one year intervenes without treatment. Immediate results after treatment revealed that the SCIS curriculum produced greater critical thinking skills than the textbook program but this finding did not hold one year later. Further longitudinal research on the critical thinking skills of children using an activity oriented science program is sorely needed.

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A SUGGESTED SUCCESS MODEL FOR THE INITIAL IMPLEMENTATION OF SCIS IN AN URBAN SETTING

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Objectives and Rationale

In these days of defeated school budgets and demands for greater fiscal accountability, school districts are forced to investigate every possible means of conserving tax dollars. A school system can no longer afford to experiment with costly, district-wide trial programs. This is particularly true in the case of material centered science curricula such as the Science Curriculum Improvement Study (SCIS). The alternative to a massive and risky trial implementation could lie in a more limited and carefully thought out approach.

The purpose of this study was twofold:

1. to identify which combination of preselected teacher and school variables had the most positive effect on student outcomes in SCIS within a large urban setting, and

2. to use these identified variables, i.e., success profile, as a model for the selection of a few schools in which the initial trial implementation of SCIS could occur.

Methodology and Design

The variables observed on 4100 fifth and sixth grade SCIS students were: attitude toward SCIS, student achievement in SCIS life science and SCIS physical science. The variables observed on the 160 teachers involved in the study were: the grade taught, if the teacher was trained in SCIS methods and materials, the age of the teacher, years of teaching experience, the number of college hours in science content and science methods, minutes per week spent on SCIS in the classroom, the number of life and physical science chapters taught, the teacher's attitude toward SCIS, the teacher's scores on the life and physical science tests. Other variables observed were: the SCIS consultant's perception of the school's interpersonal climate; the principal's attitude toward science; the school's size; the school's racial ratio and the school's socioeconomic status as measured by Title I funding. Stepwise multiple regression analysis was used to initially clarify the statistical significance of the independent variables in reference to the dependent variables. The significant independent variables for each dependent variable were then combined with the categorical treatment variables training and Title I to create trait X treatment interaction terms. Stepwise multiple regression analysis was then used to determine which of the single variables and their interaction terms were significant when considered together against each dependent variable.

Instruments and Data

The teacher data was gathered by means of a teacher questionnaire, an attitude toward SCIS instrument, SCIS life and physical science instruments. The student data was gathered via a student attitude toward SCIS instrument and SCIS life and physical science instruments. Other data were obtained from school records.

Results and Conclusions

The following variables were identified with positive student outcomes in SCIS:

1. Teacher age (average) = 35 years
2. Teacher's years experience (average) = 9 years
3. School interpersonal climate = positive, cooperative at all levels
4. Principal attitude toward elementary science = positive
5. School socioeconomic status = middle-upper socioeconomic status
6. Teachers should be competent in SCIS concepts and processes
7. Teachers should have SCIS training
8. Physical science should be taught before the life science unit.

In conclusion, it is recommended that the above variables be included in a success profile model to be used in the selection of schools for an initial implementation of SCIS in a large urban school district.

CONCURRENT SESSION G

Session G-4 Instruction

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The Effect of Demonstration-Theory Versus Theory-Demonstration Sequences and of Expected and Discrepant Outcomes of A Demonstration Experiment on Subject's Test Scores of Bloom's Knowledge, Comprehension and Application Levels

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The Effect of Four Types of Study-Guide Questions and Structure on Learning From Written Text

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Disruptive and Helpful Testing Cues in Science: An Index by Intensity and Frequency

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THE EFFECT OF DEMONSTRATION—THEORY VERSUS THEORY—DEMONSTRATION SEQUENCES AND OF EXPECTED AND DISCREPANT OUTCOMES OF A DEMONSTRATION EXPERIMENT ON SUBJECT'S TEST SCORES AT BLOOM'S KNOWLEDGE, COMPREHENSION AND APPLICATION LEVELS

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Statement of Problem

Demonstration experiments are an important teaching tool in science. There is a considerable body of anecdotal information on how to demonstrate, when to demonstrate, what to demonstrate, and to whom to demonstrate. Much of this information is contradictory. There are two themes on which many authorities comment. First is that demonstrations are more effective if the outcome is counter-intuitive or discrepant. The second theme is that one order or sequencing of theory and demonstration is superior. The recommended sequence varies from author to author. Authors support their suggestions with rationales, but no experimental study using order and discrepancy as variables has been reported. Demonstrations are performed daily in thousands of science classes. Experimental evaluation of the importance of order of presentation and discrepancy of outcome would be useful to teachers making decisions about what type of demonstration to present and how to sequence the material.

Design

A 2 x 2 multivariate design with three dependent variables and two covariates and random assignment of subjects was used.

Independent Variables

1. Order of Presentation (Two levels: Demonstration-Theory, Theory-Demonstration)

2. Discrepancy of Experiment (Two levels: Expected outcome, surprising outcome).

Dependent Variables

The three dependent variables were test scores which were obtained from the subjects' responses to multiple choice questions which were written at Bloom's knowledge, comprehension, and application levels.

Covariates

1. Otis-Hennon IQ

2. Eighth grade science grade.

Classificatory Variable

Sex. The major research hypotheses were that there would be no significant (alpha $\leq .05$) differences between the groups on the three levels tested. Minor hypotheses were that no significant interactions of the independent variables, IQ, or sex would be found. A power of .90 was estimated.

The purpose of the study was to provide useful information to teachers using demonstrations, not to test any particular theory. However, Ausubel's advance organizer theory would predict that the theory—demonstration order would produce higher test scores. Festinger's theory of cognitive dissonance would predict that the discrepant experiment would produce higher test scores.

Procedure

A script was prepared for an experiment demonstrating the solubility of gases as a function of temperature. The script was written in two separate sections. The theory section was written on an abstract level and presented concepts which explained the demonstration. The demonstration section was written on the concrete level and referred to observable phenomena. Two different sets of chemicals were used to produce two demonstration tapes with identical scripts but different discrepancy levels.

The scripts were performed by an actor, and were recorded on color videotape. The tape was duplicated and edited to produce four five-minute treatments.

A pilot study was used to evaluate and refine multiple choice questions on the knowledge, comprehension and application levels which were designed to measure the learning outcomes of the videotape.

The final instrument consisted of 35 multiple choice items. It was given to 113 average and above average eighth grade students immediately after the videotape presentation. Twenty-eight subjects had been randomly assigned to each of the four treatment groups.

Results

A MANOVA analysis revealed no significant differences in multiple choice measures of knowledge, comprehension, or application scores as a function of different orders of presentation or of different levels of discrepancy for a videotaped demonstration of an experiment in science.

THE EFFECT OF FOUR TYPES OF STUDY-GUIDE QUESTIONS AND STRUCTURE ON LEARNING FROM WRITTEN TEXT

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Objective

The purpose of the study was to investigate the effects of study questions in different forms (verbatim, true/false, paraphrased, and open ended) on the learning of science content from written text. A second purpose was to measure the effect of specifying answer location on question effectiveness.

Rationale

Study guides in the form of questions are often used to aid students' progress through science text materials but variables determining their effectiveness are largely unmeasured. Studies have shown that higher level questions produced better scores on an evaluation level posttest without a decrement in knowledge level performance. In particular, one showed that subjects producing their own examples of a principle scored higher than a control and recall condition (Watts and Anderson, 1971). Verbal learning research supports these findings with "deeper levels of processing" characterized by semantic rather than orthographic processing resulting in greater retention scores (Craig and Lockhart, 1972).

An additional practice common to science classrooms is specifying the page where answers to study questions can be found. The present study investigates both these lines of research.

Method and Design

Eighty-five fourth grade students were randomly assigned to four treatment groups. Each was given a passage from the students' weekly science newsletter. The four experimental groups were given study guides with eight verbatim, true/false, paraphrased, and open ended questions, respectively. Half the students' study guides referred to the paragraph number where the answer for each question could be found (the structured condition). The result was a 4 x 2 factorial design.

Instruments

A posttest consisting of two parts was prepared. The first subtest had eight questions identical to the verbatim questions in the study guide and the second subtest had 12 incidental questions, which covered the content of the newsletter but were unrelated to the study guide questions. The Kuder-Richardson 21 reliability for the posttest was .79.

Results

Two-way analysis of variance was used to determine whether differences existed among groups, on total scores and on the verbatim and incidental subtests.

For total scores and for both subtests two-way interactions were found to be significant. For students not receiving answer location (the unstructured condition), total scores for true/false Ss were significantly higher than both verbatim and open ended; on the verbatim subtest true/false Ss scored significantly higher than verbatim; and on the incidental subtest true/false Ss scored significantly higher than all three other groups. There were no significant differences between groups of Ss receiving question locations.

For verbatim, open ended and paraphrased groups, Ss not given locations scored higher than those given locations.

Discussion

The study results raise questions about the advisability of identifying answer locations in study guides. Comparison by treatment showed the verbatim unstructured group scored higher than the verbatim structured group on all measures. Further, when comparisons by structure were made no significant differences were found for the structured group while there were differences among the unstructured group. Possible reasons may be as follows: Lack of structure required a more thorough scanning of the information in the newsletter resulting in more careful study of the information. Further, the true/false questions required more thorough processing than did the other question forms because the learner had to ascertain the veracity of the statement which resulted in higher posttest scores.

The locating of the answers for the structured group essentially neutralized the treatment effects. More careful analysis of forms of questions are required to compare their effectiveness, particularly for different age groups, before generalizations can be made.

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DISRUPTIVE AND HELPFUL TESTING CUES IN SCIENCE: AN INDEX BY INTENSITY AND FREQUENCY

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Students in science courses, as well as most other courses, are test conscious and become anxious over testing (Sarason, Davidson, Lighthall, Waite and Ruebush, 1960). Spielberger, Anton and Bedell (1975) concluded that high levels of test anxiety often have a negative effect on tests that require formal operations. McKinnon and Renner (1971) and Kolodiy (1975) reported that science tests at the college level require formal operations. Wine (1971) suggests that high test anxious (HTA) and low test anxious (LTA) students direct their attention to different testing cues. HTA students attend to disruptive cues which debilitate test completion, whereas LTA students attend to helpful cues which facilitate test completion. Spielberger (1972) and Anton (1976) state that there is a vital need to isolate actual testing cues, disruptive and helpful, by intensity and frequency that students who differ in levels of test anxiety direct attention to.

The primary purpose of this study was to develop an objective measure that will accurately assess the types of testing cues by intensity and frequency for HTA and LTA students.

The sample consisted of 400 students in two physical geology classes. Data was collected during two sessions. The first session was designed to obtain a measure of test anxiety for each student. The second session was designed to index testing cues by intensity and frequency. A 42 percent return was obtained.

The State-Trait Anxiety Inventory (STAI) developed by Spielberger, Grosuch and Luskene (1970) is a self-report instrument that measures an individual's personality trait of test anxiety. A median-split was performed (Hays, 1973, p. 218) to obtain levels of test anxiety (HTA and LTA). Disruptive and helpful testing cues were obtained from an earlier study. At that time, HTA and LTA students were queried as to the things they felt were extremely disruptive and helpful to their test performance. A list of 55 testing cues, disruptive and helpful was obtained. The 55 testing cues were then used to construct the Test Cue Identification Questionnaire (TCIQ). The questionnaire was designed to explore the way HTA and LTA students react, intensity and frequency, to test related cues, disruptive and helpful. A sample cue and response is provided: "If a teacher asks only memory questions it is an extremely disruptive test cue 100 percent of the time.

Data was analyzed using a SPSS program for the basic statistics of cumulative frequency and mean. The results produced eleven significant cues, seven disruptive and four helpful, that were identified by HTA and LTA students. HTA students contributed more to the disruptive cues, whereas LTA students contributed more to the helpful cues which is supportive of earlier findings by Wine (1971).

Two major implications for science teaching are apparent in this study. First the elimination of disruptive cues and implementation of helpful cues will provide a testing environment conducive to maximum performance for both HTA and LTA students. Second, research is needed to establish what portion of the variance in science grades of introductory students is attributed to test anxiety level X type of testing cue.

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CONCURRENT SESSION G

Session G-5 Learning

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Logical Ability, Formal Thought and Achievement in Physics

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The Mole Concept: Investigation of an Hierchical Model

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The Effect of Student Manipulation of Molecular Models on Chemistry Achievement According to Piagetian Level

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LOGICAL ABILITY, FORMAL THOUGHT AND ACHIEVEMENT IN PHYSICS

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Formal operational thought in Piagetian theory has stimulated considerable interest among science educators. The theory describes formal thought in terms of increasingly integrated cognitive structures and as a sequence of stages culminating at the formal operational level. Operationally, ability to operate at this level is established by performance on tasks within schema such as combinatorial, proportional, probabilistic and correlational reasoning. These are also abilities closely associated with scientific thought. According to the theory, one's ability to function at the formal level is dependent upon the presence of a system of combinatorial logic. The ability to use propositional logic, on the other hand, has traditionally been associated with formal thought and success in science.

This study examined how the ability to use propositional logic was related to achievement in a university level physics course. The intent was to investigate the extent to which the ability to use proportional logic is a predictor of physics achievement.

The subjects were 450 students taking an introductory level physics course for science and pre-health professions majors at a large Eastern university. A test of logical operators was administered, along with a test for mathematical ability, and a battery of spatial-visual tasks. A factor analysis isolated strong logic and mathematics factors which accounted for over 50 percent of the variance.

In addition, chi-square analysis suggests a hierarchy in the ability to use certain operators and that some subset of these are the major predictors of course success. This result will be compared to the results of another study which has been conducted relating these operators to Piagetian schema.

The strong relationship of logical operators to achievement in introductory level physics courses suggests a task analysis of semester and unit examinations. This could provide significant information relating these operators to particular aspects of achievement. These results suggest, more importantly, that facility with such operators may exist as a precondition to achievement in such a course.

THE MOLE CONCEPT: INVESTIGATION OF AN HIERARCHICAL MODEL

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The main purpose of the study was to identify a learning hierarchy for the mole concept as it appears in introductory high school chemistry. A secondary purpose was to evaluate the relative importance of developmental level, in the neo-Piagetian sense, and availability of subordinate skills in the acquisition of related superordinate skills in the hierarchy.

An eight-element learning hierarchy was generated by task analysis and empirically validated by application of three methods currently proposed for this purpose. The sample consisted of 269 grade ten students in a course based on CHEM Study materials. In order to determine the degree of transfer from subordinate to superordinate skills, the sample was assigned by intact classes to one of two sub-groups. Each student in the sub-group designated as remedial was required to complete two take-home remedial units prior to instruction in the next skill. With this exception, teachers were encouraged not to depart from their usual instructional practices.

Several days prior to the start of instruction relating to the content of the hierarchy, a set of neo-Piagetian tasks and a test of second-order operations were administered. Three quizzes on skills from the hypothesized hierarchy were administered at appropriate times during instruction, followed by a final chemistry test consisting of four items on each skill. To estimate reliability of the chemistry skills tests, phi coefficients between items testing the same skill were computed. Nearly all were significant ($p \leq 0.001$). Cohen's κ was used to determine the consistency of mastery decisions for each subject on each skill. All but one estimate of κ were significant ($p \leq 0.001$).

The White and Clark, order-theoretic, and Dayton-Macready hierarchy validation methods, when applied to the final chemistry test data, yielded an hierarchy considered to be psychometrically valid which contained seven of the eight skills of the hypothesized hierarchy. The test of transfer revealed a significant relationship between gain in subordinate skills and related superordinate skills.

In addition to their use as determinants of the mastery status of individuals, the chemistry tests provided achievement scores for use in regression analyses. Parallel forms reliabilities for each skill on the quizzes and final test ranged from 0.36 to 0.74 and, with the exception of one skill, internal consistencies ranged from 0.72 to 0.92. Significant but moderate correlations (the largest being 0.43) were found between scores on each of the developmental tests and tests for each of the chemistry skills. Collectively and with one exception, the two developmental level tests accounted for 13 to 18 percent of variance for the tests of chemistry skills. When the contributions from the two developmental tests are entered into stepwise regression equations after the contributions from immediate superordinate skills (with R^2's ranging from 0.15 to 0.51), the increment in R^2 ranges from 0.005 to 0.056. The results support the suggestion that the availability of related subordinate skills is more important than learner developmental level to the achievement of the intellectual skills examined.

THE EFFECT OF STUDENT MANIPULATION OF MOLECULAR MODELS ON CHEMISTRY ACHIEVEMENT ACCORDING TO PIAGETIAN LEVEL

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In the past few years science educators have determined that many students enrolled in high school and college science courses do not think on the formal operational level (Chiappetta, 1976). Because a substantial number of concepts presented in science courses requires formal thinking several investigators have sought methods that will make formal concepts more accessible to concrete thinkers. One method that has been tested in chemistry courses is the manipulation of concrete molecular models. Results of studies in this area have been mixed. Talley (1973) showed that college student chemistry achievement on high level questions was higher with the manipulation of models. Sheehan (1970) found that both concrete and formal students profited from the manipulation whereas studies by Drugge and Kass (1978) and Goodstein and Howe (1978) fail to confirm this. The purpose of this study was to examine the effect of the manipulation of molecular models by high school students over a long period of time (entire school year) on chemistry achievement according to the student's Piagetian level. The research was sponsored by the Proffitt Foundation.

The sample consisted of 238 students enrolled in four schools (one rural, one suburban, two metropolitan) in central and south central Indiana. Seven teachers and their students participated in the study. Teacher's classes were randomly assigned to one of the two treatments.

The treatment consisted of students actively manipulating molecular models versus observing the teacher manipulate the models. Study guides for eight lessons were distributed to teachers to provide a minimum treatment base and teachers were encouraged to use the same mode of instruction with their classes throughout the year.

Students were classified as concrete, lower formal, and upper formal via scores on a modified form of the Longeot test. This test was administered at the beginning and end of the school year in order to also determine whether the treatment was effective in modifying students' Piagetian levels.

The dependent variables in this study consisted of the American Chemical Society (ACS) Achievement Test in High School Chemistry (reliability = 0.74), selected items from this same test that directly related to the study guides (reliability = 0.41), and a 39-item composite of test items embedded in eight unit tests relating to the eight units (reliability = 0.60).

Data were analyzed using 3 x 2's analyses of variances with three levels of Piagetian developmental stage and two levels of treatment. The following results were obtained.

1. Students who were classified as formal achieved significantly higher than those classified as concrete on the ACS test at the 0.001 level and on the content test at the .015 level.

2. Students in the active manipulation group performed significantly higher than those who observed manipulations on the ACS test at the 0.003 level, on the ACS subtest at the 0.05 level, and on the content test at the 0.055 level.

3. There were no significant interaction effects for the ACS test or ACS subtest but there was a significant interaction at the 0.029 level for the content test. Formal operational students benefitted more from active manipulation than did concrete students.

Results of this study confirm Sheehan's findings that manipulation of models is beneficial for both concrete and formal students. When used over a long time period the manipulation appears to improve chemistry achievement.

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RESEARCHERS POTPOURRI

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Topic: NSTA-NARST Cooperative Research Efforts

The influence of science education research on classroom teaching practice is not as great as many would like it to be. This lack of influence may be due to a number of reasons. Many feel that research findings and their implications are inadequately communicated to the classroom teachers. However, this lack of influence may also be due to the perceived lack of relevance for teachers as they look for guidance to deal with daily concerns and decisions which they face in the classroom.

A mechanism for two-way communication and cooperation between teachers and researchers is needed. This mechanism should be designed to facilitate the identification by teachers of research problems relevant to teachers needs, to insure the quality of the research in order to give valid-generalizable results, and to help in the translation of the research findings into language that connects it to classroom practice.

NARST and NSTA, through the respective research committees, are involved in a cooperative effort devoted to identifying research priorities and developing a mechanism for proposing, designing, conducting and reporting research relating to classroom practice. This would serve to establish better credibility of researchers with teachers and of teachers with researchers thus making the impact of research on classroom practice more likely. This would also increase the probability that the classroom practices would produce the desired science learning.

NARST AWARD PAPER

Presiding: John T. Wilson
University of Iowa
Iowa City IA 52242

The outstanding paper given at the 1978 annual meeting will be presented again and discussed.

CONCURRENT SESSION H

Session H-1 Paper Set: The Status of Pre-College Science, Mathematics, and Social Science Education, 1955-1975

Presiding:

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The Status of Pre-College Science, Mathematics and Social Science Education, 1955-1975: Enrollment and Financing

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The Status of Pre-College Science, Mathematics and Social Science Education, 1955-1975: Practices and Needs Assessments

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The Status of Pre-College Science, Mathematics and Social Science Education, 1955-1975: Science Teacher Education

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THE STATUS OF PRE-COLLEGE SCIENCE, MATHEMATICS AND SOCIAL SCIENCE EDUCATION, 1955-1975: ENROLLMENT AND FINANCING

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The two decades, 1955-1975, marked the first major investment of federal monies directly in curricular and instructional concerns. The Elementary and Secondary Education Act (ESEA) of 1965 continued the pattern of direct investment, initiating programs to deal with special groups within the educational community. Concern for the educational needs of students and for program effectiveness evaluation was specifically mandated within this Act.

Data analyzed indicate enrollments in public schools increased until 1969 and then began to decline. When data for only grades K-6 are analyzed, peak enrollment appeared to occur in 1968. Current projections for enrollment will be discussed and their implications for science education highlighted.

When financing and school control are considered, a pattern of increasing state control becomes evident. States vary extensively in the amount of control exerted over the science curriculum. In addition, method of control varies in legislative and regulatory forms. Examples of state influence or control will be discussed as these related to school size and consolidation, school curriculum, teacher certification, textbook and instructional materials selection, and minimum competentices and accountability.

THE STATUS OF PRE-COLLEGE SCIENCE, MATHEMATICS, AND SOCIAL SCIENCE EDUCATION, 1955-1975: PRACTICES AND NEEDS ASSESSMENTS

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This study was one of three funded by the National Science Foundation in the summer of 1976 to assess practices in pre-college education and to provide baseline information on needs so future programs in science, mathematics, and social science education can be targeted to meet documented national concerns.

The specific purpose of the study was to:

1. review, analyze, and summarize appropriate literature related to pre-college science instruction, to science teacher education, and to needs assessment efforts; and

2. identify trends and patterns in the preparation of science teachers, science teaching practices, curriculum materials, and needs assessments in science education

during the period 1955-1975.

Because this was an archival study, the procedures focused on identifying, retrieving, and analyzing existing literature rather than on generating new information. Major sources of information included the ERIC data base, Education Index, Reader's Guide to Periodical Literature, Dissertation Abstracts International, published books and journals, federal agencies' files and collections, state department of education archives, and reports from conferences and committees. Selection of documents for review was based upon:

1. generalizability of results based upon size of population, sampling techniques, and methods of analysis;

2. summarization of data or research reports (e.g., reviews of research);

3. importance or significance as indicated by publication in a refereed journal or as a committee report; and

4. representativeness of a type or kind of document (e.g., curriculum guide).

The reports will be organized around four major considerations:

1. Existing Practices and Procedures in Schools
2. Science Teacher Education
3. Controlling and Financing Education
4. Needs Assessment Efforts

This paper in the paper set will focus on practices and needs assessment efforts in science education. Findings summarizing the literature in each category will be presented.

THE STATUS OF PRE-COLLEGE SCIENCE, MATHEMATICS AND SOCIAL SCIENCE EDUCATION, 1955-1975: SCIENCE TEACHER EDUCATION

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The two decades, 1955-1975, are unparalleled in the degree of activity in science education. Millions of dollars were devoted to the cooperative involvement of scientists, educators, and learning theorists in the development of science curriculum materials. Extensive programs were developed and conducted to upgrade and update the science content background of teachers and to train them in the use of the new curricula.

The focus of this project was a status report on the impact of such activity in curriculum development, teacher education, instruction, and needs assessment. Specifically, the purpose of this project was to:

1. review, analyze, and summarize appropriate literature related to pre-college science instruction, to science teacher education, and to needs assessment efforts; and
2. identify trends and patterns in the preparation of science teachers, teaching practices, curriculum materials, and needs assessments in science education

during the period 1955-1975.

This paper in the set will focus on literature related to science teacher education: pre-service and in-service. Included in the survey are documents on guidelines for teacher education programs in science, certification requirements, program descriptions, research studies, and position papers. Findings summarizing the literature in each category will be presented.

CONCURRENT SESSION H

Session H-2 Paper Set: Factors Affecting Achievement in Science

Presiding:
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Analogy and Physics Achievement

Morris A. Enyeart
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Spatial Reasoning and Formal Thought as Factors in Science Achievement for New Zealand Students

Michael D. Piburn
Rutgers University
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The Effect of A Community College Education on the Cognitive Development of Students in Liberal Arts and Laboratory Technology Curricula: An Intervention Study

Alan Sherman
Dept. of Science and Humanities Education
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The Relationship of Piagetian and Piagetian-Like Tasks to Physics Achievement

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Evaluator:
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ANALOGY AND PHYSICS ACHIEVEMENT

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Objectives and Rationale

Given the fact that the use of analogies is one of the most common forms of presenting new concepts in science texts, it is surprising to find that most of the research in analogical reasoning has been with formal analogies of the A:B::C:D type and not with the paragraph form used by science texts. Studies that have dealt with analogies of the latter type have generally arrived at the same conclusion; e.g., the use of analogies does not aid comprehension of the desired concept.

This study was designed to investigate the following:

1. Is interpretation of paragraph analogies a form of analogical reasoning?
2. When an S reads a paragraph, does he comprehend the analogy?
3. Is it necessary to be formal (Piagetian) in order to comprehend an analogy, regardless of its form?
4. Is analogical reasoning related to proportional reasoning?
5. Is physics achievement related to either form of analogical reasoning.

Methodology and Design

The sample consisted of 37 students enrolled in an introductory physics course at a large eastern university. During a three-day period, Ss were given tasks designed to measure analogical reasoning ability and Piagetian Level. Tasks and Ss were each divided into three groups. By rotating the order in which tasks were given to each group, the researcher was able to control for possible learning effects. Course achievement was indicated by individual scores on the midterm exam, final exam and total course score.

Instruments and Data

Both clinical and non-clinical tasks were administered to determine Piagetian Level with respect to proportions, combinations, permutations and probability. Analogical reasoning ability was measured using a test containing formal analogies of the type used in intelligence testing. A second test related to analogical reasoning required Ss to read a paragraph containing an analogy that had been taken from their physics text, and then select the correct analogy presented in the paragraph from a list of four formal analogies which were similar in format to those in the first analogies test.

Data was analyzed using Pearson Correlations, t-tests and factor analysis.

Results

1. Ss scores on the two analogical reasoning tests were significantly, positively correlated ($p \leq .001$).
2. Proportional reasoning and formal analogy success was significantly, positively correlated ($p \leq .001$) and loaded on the same factor.
3. Proportional reasoning and paragraph analogies were not significantly correlated and loaded on different factors.
4. Only analogies of the A:B::C:D type required the Ss to be formal in terms of Piagetian Level.
5. Both types of analogical tasks had significant, positive correlations with the physics achievement measures.
6. Ss were able to comprehend analogies when presented in paragraph form.

Conclusions

When speaking of analogical reasoning, researchers in the past have assumed there was a single set of abilities used in solving problems of this type. That this is not true is indicated by the fact that a change to paragraph form no longer necessitates the use of proportional reasoning. Nor is the paragraph form related to Piagetian Level as is the A:B::C:D type of analogy. As indicated by previous research, paragraph analogies do not aid comprehension of a concept. It is not, however, due to the fact that Ss do not understand the analogy being presented.

SPATIAL REASONING AND FORMAL THOUGHT AS FACTORS IN SCIENCE ACHIEVEMENT FOR NEW ZEALAND STUDENTS

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Research suggests that Piaget's Balance and Shadows tasks require an element of spatial reasoning for completion. It also seems reasonable to propose that formal thought and spatial reasoning may be factors in science achievement. One test case is gender-related differences in spatial and/or analytical tasks and success in science. This study was conducted to test the hypotheses that:

a. Spatial reasoning and success on Piaget's Balance and Shadows tasks are related to one another and to science achievement; and that

b. Sex-linked aspects of intellectual functioning are related to differences in success by males and females in achievement in science.

All 5th Form (year 10) New Zealand students take a national School Certificate examination which may include a General Science section. The sample for this study consists of 39 of 42 6th Form (year 11) students who were certified for University Entrance by a Christchurch High School, and had also taken the School Certificate (Science) Examination the previous year.

Measures were Piaget's Balance and Shadows, Card Rotations and Surface Development from an ETS factor-analyzed battery, and achievement on the School Certificate (Science) examination.

Success rates for this sample were high. Subjects were nearly evenly divided in number between those fully formal on either or both Piagetian measure (Formal) and those less successful (Pre-Formal). There were significant differences between scores on the Card Rotations, Surface Development, and School Certificate (Science) measures for these two groups. Significant correlations were obtained for the School Certificate (Science) Examination X Shadows, Balance and Surface Development, and for scores for Balance plus Shadows X Surface Development.

Males achieved significantly higher scores than females on the School Certificate (Science) examination and the Shadows task. A Chi-square test shows females less successful in achieving Late Formal on the Shadows task. Further analysis shows that the most favorable situation for male success on the School Certificate (Science) examination is to be Formal and above the median on the Surface Development test. In contrast, females are most seriously disadvantaged only by being Pre-Formal and below the median on the Surface Development test.

THE EFFECT OF A COMMUNITY COLLEGE EDUCATION ON THE COGNITIVE DEVELOPMENT OF STUDENTS IN LIBERAL ARTS AND LABORATORY TECHNOLOGY CURRICULA: AN INTERVENTION STUDY

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Most students who enter a community college do so to learn a profession. It is also true that a community college education tends to focus on the achievement of specific skills. But does this type of education help the student to grow cognitively? It is the purpose of this study to answer that question.

In order to answer the above question, two areas of cognitive development were studied: combinatorial logic and proportional logic. Piaget's theory of cognitive development was used as the framework to measure cognitive growth. The sample consisted of male students between the ages of 17 and 19 years old who were entering freshmen when the study began. Forty subjects were enrolled in the laboratory technology curriculum—a career oriented program, and 40 subjects were enrolled in the liberal arts curriculum—a nonscience, general education curriculum, for students who wish to transfer to upper division colleges.

Each subject was pretested at the beginning of the semester to obtain a cognitive level in combinatorial and proportional logic. Each subject was posttested at the end of the academic year. Twenty-eight laboratory technology students and 29 liberal arts students completed the study. Various hypotheses were tested to determine if the students in these two curricula were at the same cognitive level at the beginning of the academic year and to see if cognitive growth occurred by the end of the academic year. In this way it could be inferred that college curricula act as interventions to increase cognitive development. Data analysis was performed using Chi-square and other nonparametric statistics.

An analysis of the data showed that for pretests, the cognitive levels of both groups of students were the same in both combinatorial and proportional tasks. An analysis of the data showed that for the posttests the cognitive levels of both groups of students were the same for the combinatorial tasks but not for the proportional tasks. The science group did much better on the postproportional tasks than did the liberal arts group. It is argued that this is evidence that cognitive development involving proportional reasoning did occur for those students enrolled in the laboratory technology curriculum.

THE RELATIONSHIP OF PIAGETIAN AND PIAGETIAN-LIKE TASKS TO PHYSICS ACHIEVEMENT

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The purpose of this study was to identify those Piagetian and Piagetian-like tasks which are associated with success in physics so that the competencies these tasks represent can be incorporated into course work or a remediation program. It has been found that mathematical ability is a necessary but not sufficient condition for success in college physics (Hudson, 1977).

Thirty-eight students at a large eastern university enrolled in an introductory physics course participated in this study. The following tasks were given: separation of variables (Kuhn, 1977), shadows (Inhelder and Piaget, 1958), combinations and permutations after Piaget, Mr. Tall (Karplus, 1970), proportional word problems (Peterson, et al., 1978), a hypothesis testing task (Bady, 1978), and correlations (Lawson, 1978). All tasks were paper and pencil except the shadows which was administered clinically to each student.

A factor analysis was performed on the data and it was found that factor one accounted for 36.6 percent of the variance and was composed primarily of the proportional word tasks. Factor two was identified as hypothesis testing accounting for an additional 19 percent of the variance, for a total of 55.1 percent of the variance. It was not possible to identify any clear pattern on the other two factors.

Pearson correlations were also examined between the tasks, their component parts and student grades on the physics midterm and final exam. The shadow task, proportions, permutations and the hypothesis testing task all had significant correlations ranging from .62 ($p \leq .001$) to .28 ($p \leq .03$). Separation of variables and combinations did not correlate with the midterm or final exam. No sex differences were found.

From the factor analysis and the correlations it can be seen that the ability to do proportions is related to success in physics (Mr. Tall, word problems and shadows). However, it remains to be seen how much of the proportional ability is a reflection of a broader requirement of physics, namely mathematical ability. Formal operational thought is also related to success in physics (shadows and hypothesis testing task).

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CONCURRENT SESSION H

Session H-3 Learning

Presiding: Juanita Chitwood
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Sex Differences Among Early Adolescents in Learning a Spatial Visualization Skill

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The Effects of Setting Novelty and Number of Available Relevant Examples on Field Trip Behavior and Learning

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Sex-Related Differences in Rate of Concept Attainment

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SEX DIFFERENCES AMONG EARLY ADOLESCENTS IN LEARNING A SPATIAL VISUALIZATION SKILL

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Objectives and Rationale

Adolescent and adult males have consistently outperformed females on tests of spatial ability; but a similar difference, if one exists, has not been so consistently found among children (Maccoby and Jacklin, 1974). Although a sex difference appears to be well substantiated for people at some, if not all, ages, the relationship of sex and instruction to spatial ability has been little understood (Eliot and Fralley, 1976). Smith and Schroeder (1978) found that fourth grade boys and girls did not differ in a two-dimensional spatial visualization task based on Elementary Science Study's *Tangrams* (1976); and both sexes improved significantly as the result of instruction.

Since sex differences in spatial ability had been found among adolescents but not among children (up through the fourth grade), and since instruction had been shown to have a positive effect among fourth grade girls and boys, the present authors asked (1) whether a sex difference in spatial ability existed among early adolescents (sixth and seventh graders) and (2) whether their spatial ability would be differentially affected by instruction.

Methodology, Design and Instrument

In order to answer these questions, a 2 x 2 factorial design with spatial ability as the criterion variable was used. Main effects were sex and instruction (i.e., whether or not instruction was received prior to the criterion test). Spatial ability was measured by the Spatial Visualization Abilities Test, SVAT (Smith and Schroeder, 1978). The SVAT presents the student with three progressively more difficult *Tangram* puzzles and measures the total time taken to complete the puzzles. Instruction in spatial visualization took place over four one-hour periods on succeeding days and followed the description of instruction by Smith and Schroeder (1978) which emphasized skills needed to solve *Tangram* puzzles. Boys (N = 32) and girls (N = 27) were randomly assigned to the instruction or noninstruction groups. The study was conducted in a parochial school primarily serving blue collar families in a medium-sized midwestern city.

Results

An analysis of the SVAT data showed a significant interaction between sex and instruction ($F = 4.89$, $p \leq .05$). Post hoc analysis, using the Scheffé method, showed that noninstructed girls significantly outperformed noninstructed boys ($F = 15.74$, $p \leq .05$); and instructed boys significantly outperformed noninstructed boys ($F = 12.14$, $p \leq .05$). All other pairwise comparisons were not significant.

Conclusions

Contrary to the findings of previous studies, early adolescent girls outperformed boys of the same age in a spatial abilities task prior to instruction. Whereas Smith and Schroeder (1978) had found that instruction significantly improved the spatial ability of both male and female fourth graders, the present study found that similar instruction of slightly older students (i.e., sixth and seventh graders) led to significant improvement only for the boys.

Implications

The results of this study, when coupled with the findings of Smith and Schroeder (1978), indicate that instruction in spatial visualization ought to be provided in the fourth grade (prior to adolescence), if both girls and boys are to benefit significantly from the instruction.

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THE EFFECTS OF SETTING NOVELTY AND NUMBER OF AVAILABLE RELEVANT EXAMPLES ON FIELD TRIP BEHAVIOR AND LEARNING

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The purpose of this study was to investigate the combined effects of two environmental variables—setting novelty and setting relevance—that are commonly assumed to be important to the educational process in general and that are often used to justify field trips. The relative novelty of the physical environment for a learning task has previously been shown to have significant effects on children's overt behavior and cognitive learning, both in the laboratory and in outdoor settings (Falk, Martin and Balling, 1978; Lubow, Rifkin and Alck, 1976). Although rarely investigated, the relevance of the setting for learning the material presented to the student is also an important variable to consider, especially since the reason most educators give for conducting outdoor based learning activities is that more concrete examples of natural phenomena can be discovered outside, rather than inside, the classroom. Based upon Berlyne's (1960) theorizing, it was hypothesized that students unfamiliar with complex natural settings, such as forests, should benefit most from outdoor field trips to relatively simplified biological environments with a small number of highly salient real-world examples relevant to the lesson being taught. On the other hand, students with more experience in natural environments should perform better in complex environments that can remain interesting with repeated exposure and where some of the subtleties of the natural world can begin to be appreciated.

The activity selected for this study was designed to help children understand the diversity, structure, and function of trees in an ecosystem. Children compared leaf shapes, trunk diameters, bark textures, and bark colors among many trees. In order to manipulate the number of relevant examples, three different settings, which varied greatly in the number of trees they contained, were used, namely a small urban park on a busy street corner, a quiet suburban park, and a mature forest area within a very large park. The relative novelty of the environment was varied by using subjects who, by virtue of their place of residence, were differentially familiar with the experimental settings. Samples were drawn from urban, suburban, and rural populations of children, roughly equivalent in socioeconomic status. Thus, three levels of setting relevance, as defined by the number of examples (trees) available for study, and three levels of familiarity with the setting were manipulated in a factorial design. The students in a total of 15 fifth and sixth grade classrooms were used as subjects. Each class was divided into thirds, and the children in each group were assigned to do the field trip activity in one of the three experimental locations. For all subjects, the experimental task was done in the context of an all-day field trip away from school. Pretests were given to the subjects several weeks in advance of the trip in order to determine their knowledge of the three settings and the material to be learned in the activity, as well as the extent of their outdoor experience. A posttest, which was designed to measure both cognitive learning and attitudes, was given to the subjects immediately following the activity. Observations of student behavior during the activity were also taken.

A discussion of results will be presented, including the analyses of the cognitive, affective, and psycho-motor behaviors of elementary school students on outdoor science field trips as a function of setting novelty and relevance. The nature of the interaction of these two environmental variables will also be discussed. A theoretical model that should provide pedagogical guidelines for field trip site selection will be presented.

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SEX-RELATED DIFFERENCES IN RATE OF CONCEPT ATTAINMENT

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Rationale

Sex differences in performance, favoring boys, have been reported for several Piaget tasks which are closely related to concepts and topics in the science curriculum. The poorer performance of girls may be interpreted as reflecting an experiential deficit (an environmental factor) or a slower developing mental structure (a genetic factor). If the difference is due to a lack of necessary experience on the part of girls, then they should perform as well as boys on the tasks if they are given the prerequisite experiences. If, on the other hand, they lack the requisite mental structure, then the provision of experiences should not make a significant difference in their performance on the tasks.

Objectives

The purpose of the present study was to find some evidence which might be brought to bear on the issue raised above. Answers were sought to the following questions: (a) Is there a sex-related difference at ages 9-11 on response to a volume-density task? (b) Will performance on the task be affected by classroom instruction? (c) Will performance of boys and girls be affected similarly?

Method

Data collected from two groups of children were used. The 64 children in Group I were pretested, taught a series of lessons which provided what was thought to be relevant experience, and posttested. The time which elapsed from pretest to posttest was seven months. Their posttest scores were compared to scores of children of similar age who had not received the specified instruction. The 96 children in Group II were divided into experimental and control groups, pretested, taught a series of lessons similar to those taught to the children of Group I, and posttested. The elapsed time from pretest to posttest was one month.

Instruments

Similar tests of conservation of volume and density, composed of items derived from Piagetian literature, were administered to the two groups. The experimenter demonstrated the tasks to one class at a time; children marked answers on response sheets. Test-retest reliability and item analysis data are available for both tests. The data were analyzed by means of analysis of variance and correlational techniques.

Results and Conclusions

The previous findings of significant sex differences were confirmed. A significant training effect, as shown by improved performance of those who had received instruction, was also found. The scores of both boys and girls improved after instruction but, although the girls' scores improved more than the boys', the difference was not statistically significant. The girls were at approximately the same level after instruction as the boys had attained before instruction.

Results are interpreted as favoring an interactive model of development in which experience and structure cannot be separated since structure is built as a result of experience and the manner and degree to which experience is assimilated is determined by the structure already present. Implications for curriculum development will be discussed.

CONCURRENT SESSION H

Session H-4 Instruction

Presiding: William C. Ritz
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The Effects of Diagnosis, Remediation and Locus of Control on Achievement, Retention, and Attitudes of Middle School Science Students

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The Effects of a Diagnostic-Prescriptive Teaching Strategy on the Achievement and Attitudes of High School Biology Students

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The Effects of Diagnostic Prescriptive Instruction and Locus of Control on Different Cognitive Levels of Science Achievement in University Students

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THE EFFECTS OF DIAGNOSIS, REMEDIATION, AND LOCUS OF CONTROL ON ACHIEVEMENT, RETENTION, AND ATTITUDES OF MIDDLE SCHOOL SCIENCE STUDENTS

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Objectives and Rationale

The objectives of this study were to determine the effects of diagnostic testing followed by prescribed remediation on the immediate and retained science achievement of middle school students, and to determine if effects of treatment were consistent across student's race and locus of control (LOC) levels.

In the main, achievement tests are used as summative measures for the purpose of determining what students know and for assigning grades. An equally viable purpose of testing is to provide diagnostic information to guide remediation activities. Formal diagnosis can pinpoint misconceptions and learning difficulties and allow for prescribed remediation prior to summative evaluation.

The degree to which a student acts on the feedback from diagnostic testing and attends to the remediation may depend on special characteristics of the learner. One of these is locus of control. It is possible that "internal" individuals will act more readily upon the feedback and opportunity for remediation, while "external" persons might view their learning success as being more controlled by others and not attend to the feedback.

Methodology and Design

The three independent variables in this study were: type of diagnostic-remediation treatment, level of locus of control, and race of student. Three intact classes (N = 76) were randomly assigned to the following treatment levels:

> COMPARISON LEVEL: OBJECTIVES ONLY. Subjects in this group received a set of 27 objectives followed by three weeks of instruction (on the first 15 objectives), the first summative test, two more weeks of instruction, then the second summative test. Instruction included lecture, reading, and viewing filmstrips and slides, and observing laboratory demonstrations.
>
> EXPERIMENTAL LEVEL I: DIAGNOSTIC LEVEL. These subjects received the same objectives and instruction as the "objectives only" group. In addition, this group received a diagnostic measure after each set of five objectives.

> Students who failed to master an objective were so informed and required to take a second parallel diagnostic measure two days later. No suggestions for remediation were given.
>
> EXPERIMENTAL LEVEL II: DIAGNOSTIC/REMEDIATION LEVEL. Subjects in this group received the same treatments as the first two levels with the exception that students who failed to master an objective on the first diagnostic measure were given remedial assignments to complete before taking the second diagnostic measure.

Data were analyzed using ANCOVA procedures in a 3 x 2 x 2 (treatment x LOC x race) factorial design. As mentioned above, there were two experimental groups and one comparison group. In addition, each group was stratified on two levels of locus of control (internals and externals) and two levels of race (black and white). Pretreatment achievement data were used as the covariates.

Instruments and Data

A series of parallel items was developed for use as diagnostic, achievement and retention test items. No item was used twice. The content validity of the items was insured by comparing them to the specific objectives. The KR_{21} reliabilities of the three achievement tests were .94, .74 and .94. The first summative test was administered after three weeks of instruction and the second at the end of five weeks. The retention measure was administered to all three groups one month after the end of treatment.

Prior to treatment, data on the locus of control variable were collected with a modified, Rotter LOC measure. Student's attitude toward the use of objectives, diagnosis and remediation was measured using Likert scale items.

Results

Although immediate achievement was not significantly increased by diagnostic remedial treatments ($p \leq .05$), the students who experienced diagnostic/remedial instruction showed a 10-12 percent greater retention of science concepts ($p \leq .05$).

Also, on the second summative measure and on the retention measure, internal LOC students scored significantly higher than external students ($p \leq .05$). On the second summative measure, the diagnostic treatment favored internal subjects slightly more than external subjects ($p \leq .05$).

White students showed greater retention than blacks but a significant treatment by race interaction indicated that these differences were reduced through the use of diagnostic remedial instruction ($p \leq .05$).

Although there was no affective impact of treatment, race, or LOC, the attitudes of the students were positive.

Conclusions

Both internals and externals, and blacks and whites, benefitted from diagnosis, and diagnosis and remediation. It should also be noted that retention differences between blacks and whites were reduced by the use of remediation. The use of diagnostic remedial strategies proved to be more effective than not using them; therefore, these methods should be considered as a means of improving retained achievement in middle school science classes.

THE EFFECTS OF A DIAGNOSTIC-PRESCRIPTIVE TEACHING STRATEGY ON THE ACHIEVEMENT AND ATTITUDES OF HIGH SCHOOL BIOLOGY STUDENTS

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Objectives and Rationale

In order to provide instruction based on individual need, teachers can employ methods to determine the entry level capabilities of pupils before instruction begins and to monitor pupil progress as instruction proceeds. It is further suggested that teachers then prescribe instruction based on the needs identified from diagnosis of the individual learner. This strategy is defined as diagnostic-prescriptive (d-p) teaching.

Variations in types of d-p assistance give rise to a variety of questions or concerns. Can the task of d-p management be delegated to students with effectiveness, comparable to a teacher-managed strategy? Although diagnostic-prescriptive learning assistance may be shown to effect significant increases in achievement, is administration and management of the task an obstacle to large-scale implementation?

The degree to which a student is a successful participant in a diagnostic-prescriptive environment may depend in part on special characteristics of the learner. The personalogical variables examined as main effects in this study are aptitude and locus of control (LOC). It is possible that those individuals classified as internal with regard to LOC or high academic aptitude may exhibit a greater willingness toward participation in the d-p classroom.

The objectives of this study were:

1. To measure the effects of three variations in the use of diagnostic-prescriptive teaching, locus of control, and aptitude on the cognitive and affective biology achievement of high school students.

2. To determine if the effects of treatment (diagnostic-prescriptive teaching) were consistent across levels of student aptitude and locus of control.

Methodology and Design

The experimental sample consisted of all students (N = 93) enrolled in three Biological Sciences Curriculum Study (BSCS) biology classes. Intact classes were randomly assigned to the following treatment levels for the six weeks of this study:

> CONTROL LEVEL: No Diagnostic-Prescriptive Assistance. This level included subjects who received instruction, but did not receive diagnostic tests or any remediation prescribed by the instructor or required by virtue of objectives of the course.
>
> EXPERIMENTAL LEVEL I: Teacher Managed Diagnosis and Prescription. This level included subjects who received diagnostic tests, feedback on performance, and prescriptive remediation from the teacher.
>
> EXPERIMENTAL LEVEL II: Student Managed Diagnosis and Prescription. This level included subjects who received diagnostic tests from the teacher. Scoring the diagnostic test, assessing progress on current objectives (i.e., feedback on performance), and undertaking remediation was a responsibility delegated to the student.

Diagnosis was conducted through the use of objective-referenced, brief, pencil and paper instruments named progress checks to convey the notion to students that there was no penalty for the identification of their learning problems.

All subjects were stratified on measures of aptitude (high, middle, and low) and locus of control (internal and external). This permitted measures of the dependent variables to be analyzed within a 3 x 3 x 2 factorial design which consisted of three levels of treatment, three levels of aptitude, and two levels of locus of control.

Data were analyzed through analysis of variance, analysis of covariance, and selected multiple comparison procedures. Pre-treatment achievement data were used as the covariates.

Instruments and Data

Three measures pertaining to biology achievement were used in the study: (a) pre-treatment biology achievement scores to be used as covariates, (b) treatment-period biology achievement scores to be used as criterion variables, and (c) a measure of attitudes toward biology content and instruction. Content validity of the cognitive tests was established by comparing items to the specific objectives. KR_{20} and KR_{21} reliability estimates of the various measures ranged from .71 to .91.

Prior to treatment, aptitude data was collected by use of the School and College Ability Test (SCAT). Locus of Control orientation was assessed by administering the Rotter I-E Scale.

Results and Conclusions

Significant treatment effects were detected on all four measures. The effects of aptitude and locus of control, when adjusted for pre-treatment differences, proved to be non-significant. A significant treatment by locus of control interaction was detected on the first cognitive measure. The group receiving teacher-managed learning assistance scored higher on all cognitive measures. On the other hand, those students managing their own learning-assistance system held a more positive viewpoint in attitudes toward biology content and instruction.

THE EFFECT OF DIAGNOSTIC PRESCRIPTIVE INSTRUCTION AND LOCUS OF CONTROL ON DIFFERENT COGNITIVE LEVELS OF SCIENCE ACHIEVEMENT IN UNIVERSITY STUDENTS

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Objectives and Rationale

In the main, achievement tests are used as summative measures for the purpose of determining what students know and assigning grades. An equally viable purpose of testing is to provide diagnostic information to guide remediation activities. Formal diagnosis can pinpoint misconceptions and learning difficulties and allow for prescribed remediation prior to summative evaluation.

The degree to which a student acts on the feedback from diagnostic testing and attends to the remedial assignment may depend on special characteristics of the learner. One of these is Locus of Control. It is possible that the "internal" individual will act more readily upon the feedback and opportunity for remediation, while an "external" person might view their learning success as being more controlled by others and not attend to the feedback.

The objectives of this experimental study were to determine the effects of objective referenced formative diagnostic testing followed with remediation assignments on three cognitive levels of science achievement and the attitudes of university students, and to determine if the effects of treatment were consistent across student locus of control levels.

Methodology and Design

The independent variables in this study were type of instructional treatment and level of locus of control. The treatment levels are defined as follows:

> COMPARISON LEVEL: OBJECTIVES ONLY (O). The usual procedure in the course was to provide each student with performance objectives which guided instruction and student evaluation. The instructional unit used in the study consisted of 16 objectives. The subjects in this treatment level received the usual unit objectives and experienced instruction which included lecture-discussions, a slide tape presentation, two laboratory sessions and one homework assignment. The instructional procedures were not unique to the unit; the sessions were considered normal for the course.

EXPERIMENTAL LEVEL: DIAGNOSIS AND PRESCRIPTION (DP). Subjects in this treatment level received the same objectives and instruction as the above group and followed an identical time schedule. In addition, they completed regular diagnostic measures which were keyed to the objectives and received remedial assignments when necessary.

The diagnostic activities occurred during the first five minutes of each session. Each student completed a short quiz on the objectives covered during the prior session. The quizzes were then marked by an assistant while the students were engaged in instruction toward the next subset of objectives.

For each of the objectives, two remedial assignments had been selected. Each subject had a file folder from which he obtained the diagnostic measure at the beginning of the session and the necessary remedial assignments at the end of the session. If a student received a remedial assignment, he was rediagnosed on those objectives the next session along with the diagnosis for the subset of objectives. Students were not required to master the objectives before the class proceeded. Also, no time was taken to reteach an objective. Remediation was prescribed by the instructor but was the responsibility of the student.

Data Sources

The subjects in the study were 60 university students enrolled in an introductory biology course at the University of Georgia. Pretreatment data were collected on the average achievement level of each student on the units of study covered prior to experiment conditions. These data were used as covariates to adjust for selection bias and increase statistical power of the analysis. Pre-treatment data were also collected on student Locus of Control as assessed by the Rotter LOC Measure. Subjects were then stratified as internal or external. Post treatment achievement data at three cognitive levels (i.e., knowledge comprehension, and higher) were collected at the end of the unit along with affective data to measure the subjects' attitudes toward the nature of the instruction.

All measures were item analyzed to insure adequate reliability and validity.

Results

ANCOVA procedures indicated that, on the total achievement measure, the DP group achieved significantly higher than the Objectives Only group ($p \leq .04$). This difference represented a 10 percent increase in achievement. When the cognitive level subtest data were analyzed, the differences in achievement existed in the recall level items ($p \leq .05$). No other influences of treatment on achievement existed.

And, no effects on locus of control on achievement or LOC by treatment interactions were found. Although the mean attitude scores were positive, there were no significant differences in attitude which could be attributed to treatment.

Importance

The results of this study indicate that science achievement can be increased with the use of diagnostic prescriptive instruction; although, the greatest impact appears to be on low level learning. Also, the effects of treatment are consistent across internal and external students and bring about achievement gains with no decline in the affective dimension. With the present concern over declining achievement in the sciences, the treatment investigated in this study deserves serious consideration as a means of improving achievement.

CONCURRENT SESSION H

Session H-5 Round Table: Annual Review of Science Education Research

Presiding:

Glen Aikenhead
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Reflections on Writing an Annual Review and Summary of Research in Science Education

Rita W. Peterson
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Evaluator:

William Brown
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REFLECTIONS ON WRITING AN ANNUAL REVIEW AND SUMMARY OF RESEARCH IN SCIENCE EDUCATION

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As competing demands for our time increase, so does our reliance on reviews of research for keeping abreast of the important trends and issues in areas of our professional interest. Yet, authors and readers of annual reviews or periodic summaries of research presently face some serious problems which require discussion.

The purpose of this round table discussion is to promote the exchange of information. First, one author of a recent annual ERIC review will provide an inside view of the task of reading, summarizing and synthesizing the research in science education for one year, and will share some concerns about problems that may increasingly confront those who rely on research reviews in their work. Second, those who are familiar with annual or periodic reviews of research will be encouraged to discuss these problems and share their views on how such publications might become more useful.

The initial thrust of the round table discussion will be directed toward two concerns that grew out of writing the most recent annual review of research for ERIC. The major problem facing the research community in this last quarter of the twentieth century, in the author's view, is how to deal with the knowledge explosion that has resulted from multivariate analysis research. We are faced with the fact that we are living in a multivariate research age and still trying to communicate in a univariate language. To illustrate, readers expect to read reviews that synthesize research in traditional categories like achievement or attitudes. Yet reviewers are increasingly met with studies which report multiple outcomes in achievement, attitudes, self-concept, and locus of control, in a single study which may involve a highly diverse population (e.g., varied in age, gender, ethnicity, affluence, reading level, etc.), with numerous interactions among dependent and independent variables. The problems associated with synthesizing multivariate studies or failing to account for their results in this knowledge explosion will be discussed in relation to improving communication in our research reviews.

A second problem which has concerned reviewers of research for much longer is the weakness or absence of theory among studies. More recently, a related concern is the alleged decline in basic or "pure" research itself. Kerlinger's paradox will be discussed: that if one wishes to increase the long-term impact of research in schools, one should invest in basic research, not applied research. The short-term "pay-off" and "relevance" of applied research versus the long-term value of basic research will be discussed in relation to standards for reporting or reviewing research in journals.

GENERAL SESSION III

Presiding:
John W. Renner, President
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Topic:
The Impact of Paradigm-Based Research
Upon Classroom Practice

Speaker:
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